Technology and Global Issues

IENG 400

Professor

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COLLEGE OF ENGINEERING
& COMPUTING SCIENCES

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ISSUE

Do We Have a Population Problem?

YES: Dennis Dimick, from "As World's Population Booms, Will Its Resources Be Enough for Us?" *National Geographic* (2014)

NO: Tom Bethell, from "Population, Economy, and God," *The American Spectator* (2009)

Learning Outcomes

After reading this issue, you will be able to:

- Explain why unrestrained population growth is not sustainable.
- Explain why past predictions of population disaster have not come true.
- Explain the potential benefits of stabilizing or reducing population.
- Explain the potential drawbacks of stabilizing or reducing population.

ISSUE SUMMARY

YES: Dennis Dimick argues that new projections of higher population growth through the twenty-first century are reason for concern, largely because of the conflict between population size and resource use. The environmental impact of population also depends on technology, affluence, and waste, but educated women have smaller families and technology (electric lights, for instance) aids education. Controlling population appears to be essential.

NO: Tom Bethell argues that population alarmists project their fears onto popular concerns, currently the environment, and every time their scare-mongering turns out to be based on faulty premises. Blaming environmental problems will be no different. Societies are sustained not by population control but by belief in God.

In 1798 the British economist Thomas Malthus published his *Essay on the Principle of Population*. In it, he pointed with alarm at the way the human population grew geometrically (a hockey-stick-shaped curve of increase) and at how agricultural productivity grew only arithmetically (a straight-line increase). It was obvious, he said, that the population must inevitably outstrip its food supply and experience famine. Contrary to the conventional wisdom of the time, population growth was not necessarily a good thing. Indeed, it led inexorably to catastrophe. For many years, Malthus was something of a laughing stock. The doom he forecast kept receding into the future as new lands were opened to agriculture, new agricultural technologies appeared, new ways of preserving food limited the waste of spoilage, and the birth rate dropped in the industrialized nations (the "demographic transition"). The food supply kept ahead of population growth and seemed likely—to most observers—to continue to do so. Malthus's ideas were dismissed as irrelevant fantasies.

Yet overall population kept growing. In Malthus's time, there were about 1 billion human beings on Earth. By 1950—when Warren S. Thompson worried that civilization would be endangered by the rapid growth of Asian and Latin American populations during the next five decades (see "Population," *Scientific American*, February 1950)—there were a little over 2.5 billion. In 1999 the tally passed 6 billion. It passed 7 billion in 2011. By 2025 it will be over 8 billion. Until fairly recently, most experts thought that population would peak at about 9 billion around 2050 and then begin to level off and even decline. Some projected a 2100 world population of about 10 billion; see

Jocelyn Keiser, "10 Billion Plus: Why World Population Projections Were Too Low," *Science Insider* (May 4, 2011) (http://scim.ag/_worldpop). However, in 2014 the United Nations released estimates indicating that population would not level off before 2100. Indeed, it could reach 12 billion, or even a bit more, largely due to continuing high growth rates in Africa; see Patrick Gerland, et al., "World Population Stabilization Unlikely This Century," *Science* (October 10, 2014).

While global agricultural production has also increased, it has not kept up with rising demand, and—because of the loss of topsoil to erosion, the exhaustion of aquifers for irrigation water, and the high price of energy for making fertilizer (among other things)—the prospect of improvement seems exceedingly slim to many observers. Two centuries never saw Malthus's forecasts of doom come to pass. Population continued to grow, and environmentalists pointed with alarm at a great many problems that resulted from human use of the world's resources (air and water pollution, erosion, loss of soil fertility and groundwater, loss of species, and a great deal more). "Cornucopian" economists such as the late Julian Simon insisted that the more people there are on Earth, the more people there are to solve problems and that humans can find ways around all possible resource shortages. See Simon's essay, "Life on Earth Is Getting Better, Not Worse," *The Futurist* (August 1983). See also David Malakoff, "Are More People Necessarily a Problem?" *Science* (July 29, 2011) (a special issue on population).

Was Malthus wrong? Both environmental scientists and many economists now say that if population continues to grow, problems are inevitable. But some experts still project that population will level off and then decline. Fred Pearce, *The Coming Population Crash: and Our Planet's Surprising Future* (Beacon, 2010), is optimistic about the effects on human well-being of the coming decline in population. Do we still need to work on controlling population? Historian Matthew Connolly, *Fatal Misconception: The Struggle to Control World Population* (Belknap Press, 2010), argues that the twentieth-century movement to control population was an oppressive movement that failed to deliver on its promises. Now that population growth is slowing, the age of population control is over. Yet there remains the issue of "carrying capacity," defined very simply as the size of the population that the environment can support, or "carry," indefinitely, through both good years and bad. It is not the size of the population that can prosper in good times alone, for such a large population must suffer catastrophically when droughts, floods, or blights arrive or the climate warms or cools. It is a long-term concept, where "long-term" means not decades or generations, nor even centuries, but millennia or more. See Mark Nathan Cohen, "Carrying Capacity," *Free Inquiry* (August/September 2004); T. C. R. White, "The Role of Food, Weather, and Climate in Limiting the Abundance of Animals," *Biological Reviews* (August 2008); and David Pimentel, et al., "Will Limited Land, Water, and Energy Control Human Population Numbers in the Future?" *Human Ecology* (August 2010).

What is Earth's carrying capacity for human beings? It is surely impossible to set a precise figure on the number of human beings the world can support for the long run. As Joel E. Cohen discusses in *How Many People Can the Earth Support?* (W. W. Norton, 1996), estimates of Earth's carrying capacity range from under a billion to over a trillion. The precise number depends on our choices of diet, standard of living, level of technology, willingness to share with others at home and abroad, and desire for an intact physical, chemical, and biological environment (including wildlife and natural environments), as well as on whether or not our morality permits restraint in reproduction and our political or religious ideology permits educating and empowering women. The key, Cohen stresses, is human choice, and the choices are ones we must make within the next 50 years. Phoebe Hall, "Carrying Capacity," *E—The Environmental Magazine* (March/April 2003), notes that even countries with large land areas and small populations, such as Australia and Canada, can be overpopulated in terms of resource availability. The critical resource appears to be food supply; see Russell Hopfenberg, "Human Carrying Capacity Is Determined by Food Availability," *Population & Environment* (November 2003).

Andrew R. B. Ferguson, in "Perceiving the Population Bomb," *World Watch* (July/August 2001), sets the maximum sustainable human population at about 2 billion. Sandra Postel, in the Worldwatch Institute's *State of the World 1994* (W.W. Norton, 1994), says, "As a result of our population size, consumption patterns, and technology choices, we have surpassed the planet's carrying capacity. This is plainly evident by the extent to which we are damaging and depleting natural capital" (including land and water). The point is reiterated by Robert Kunzig, "By 2045 Global Population Is Projected to Reach Nine Billion. Can the Planet Take the Strain?" *National Geographic* (January 2011) (*National Geographic* ran numerous articles on population-related issues during 2011). Thomas L. Friedman, "The Earth Is Full," *New York Times* (June 7, 2011), thinks a crisis is imminent but we will learn and move on; see also Paul Gilding, *The Great Disruption: Why the Climate Crisis Will*

Bring On the End of Shopping and the Birth of a New World (Bloomsbury Press, 2011).

Or is the crisis less urgent? Many people, relying on pre-2014 estimates of future population, think population growth is now declining and world population will actually begin to decline during this century. See Jeff Wise, "About that Overpopulation Problem," *Slate* (January 9, 2013) (http://www.slate.com/articles/technology/future_tense/2013/01/world_population_may_actually_start_declining_not_exploding.html. If they are right, there is clearly hope. But most estimates of carrying capacity put it at well below the current world population size, and it will take a long time for global population to fall far enough to reach such levels. Perhaps we are moving in the right direction, but it remains an open question whether our numbers will decline far enough soon enough (i.e., before environmental problems become critical). On the other hand, Jeroen Van den Bergh and Piet Rietveld, "Reconsidering the Limits to World Population: Meta-Analysis and Meta-Prediction," *Bioscience* (March 2004), set their best estimate of human global carrying capacity at 7.7 billion, which is distinctly reassuring. J. T. Trevors, "Total Abuse of the Earth: Human Overpopulation and Climate Change," *Water, Air, and Soil Pollution* (January 2010, Suppl. 1), is less optimistic, noting that we are in unsustainable territory and "The party [of endless growth and consumption] is over. . . . Humans cannot bribe nor buy nature."

How high a level will population actually reach? Fertility levels are definitely declining in many developed nations; see Alan Booth and Ann C. Crouter (eds.), *The New population problem: Why Families in Developed Countries Are Shrinking and What It Means* (Lawrence Erlbaum Associates, 2005). The visibility of this fertility decline is among the reasons mentioned by Martha Campbell, "Why the Silence on Population?" *Population and Environment* (May 2007). Yet Doug Moss, "What Birth Dearth?" *E—The Environmental Magazine* (November–December 2006), reminds us that there is still a large surplus of births—and therefore a growing population—in the less developed world. If we think globally, there is no shortage of people. However, many countries are so concerned about changing age distributions that they are trying to encourage larger—not smaller—families. See Robert Engelman, "Unnatural Increase? A Short History of Population Trends and Influences," *World Watch* (September/October 2008—a special issue on population issues), "Population and Sustainability," *Scientific American Earth 3.0* (Summer 2009), and his book *More: Population, Nature, and What Women Want* (Island Press, 2008). On the other hand, David E. Bloom, "7 Billion and Counting," *Science* (July 29, 2011), notes that "Despite alarmist predictions, historical increases in population have not been economically catastrophic. Moreover, changes in population age structure [providing for more workers] have opened the door to increased prosperity." Jonathan A. Foley, "Can We Feed the World & Sustain the Planet?" *Scientific American* (November 2011), thinks that with revisions to the world's agricultural systems, a growing population's demand for food can be met, at least through 2050.

Some people worry that a decline in population will not be good for human welfare. Michael Meyer, "Birth Dearth," *Newsweek* (September 27, 2004), argues that a shrinking population will mean that the economic growth that has meant constantly increasing standards of living must come to an end, government programs (from war to benefits for the poor and elderly) will no longer be affordable, a shrinking number of young people will have to support a growing elderly population, and despite some environmental benefits, quality of life will suffer. China is already feeling some of these effects; see Wang Feng, "China's Population Destiny: The Looming Crisis," *Current History* (September 2010), and Mara Hvistendahl, "Has China Outgrown the One-Child Policy?" *Science* (September 17, 2010). Julia Whitty, "The Last Taboo," *Mother Jones* (May–June 2010), argues that even though the topic of overpopulation has become unpopular, it is clear that we are already using the Earth's resources faster than they can be replenished and the only answer is to slow and eventually reverse population growth. Scott Victor Valentine, "Disarming the Population Bomb," *International Journal of Sustainable Development and World Ecology* (April 2010), calls for "a renewed international focus on managed population reduction as a key enabler of sustainable development." As things stand, the current size and continued growth of population threaten the United Nations' Millennium Development Goals (including alleviating global poverty, improving health, and protecting the environment; see http://www.un.org/millenniumgoals/); see Willard Cates, Jr., et al., "Family Planning and the Millennium Development Goals," *Science* (September 24, 2010). Paul R. Ehrlich and Anne H. Ehrlich, "Solving the Human Predicament," *International Journal of Environmental Studies* (August 2012), stress the contribution of population to environmental problems and see hope in a wide variety of grassroots movements.

In the YES selection, Dennis Dimick argues that new projections of higher population growth through the twenty-first century are reason for concern, largely because of the conflict between population size and

resource use. The environmental impact of population also depends on technology, affluence, and waste, but educated women have smaller families and technology (electric lights, for instance) aids education. Controlling population appears to be essential. In the NO selection, Tom Bethell argues that population alarmists project their fears onto popular concerns, currently the environment, and every time their scaremongering turns out to be based on faulty premises. Blaming environmental problems will be no different. Societies are sustained not by population control but by belief in God.

YES

Dennis Dimick

As World's Population Booms, Will Its Resources Be Enough for Us?

This week, two conflicting projections of the world's future population were released. . . . [A] new United Nations and University of Washington study in the journal *Science* says it's highly likely we'll see 9.6 billion Earthlings by 2050, and up to 11 billion or more by 2100. These researchers used a new "probabilistic" statistical method that establishes a specific range of uncertainty around their results. Another study in the journal *Global Environmental Change* projects that the global population will peak at 9.4 billion later this century and fall below 9 billion by 2100, based on a survey of population experts. Who is right? We'll know in a hundred years.

Population debates like this are why, in 2011, *National Geographic* published a series called "7 Billion" on world population, its trends, implications, and future. After years of examining global environmental issues such as climate change, energy, food supply, and freshwater, we thought the time was ripe for a deep discussion of people and how we are connected to all these other issues—issues that are getting increased attention today, amid the new population projections.

After all, how many of us there are, how many children we have, how long we live, and where and how we live affect virtually every aspect of the planet upon which we rely to survive: the land, oceans, fisheries, forests, wildlife, grasslands, rivers and lakes, groundwater, air quality, atmosphere, weather, and climate.

World population passed 7 billion on October 31, 2011, according to the United Nations. Just who the 7 billionth person was and where he or she was born remain a mystery; there is no actual cadre of census takers who go house to house in every country, counting people. Instead, population estimates are made by most national governments and international organizations such as the UN. These estimates are based on assumptions about existing population size and expectations of fertility, mortality, and migration in a geographic area.

We've been on a big growth spurt during the past century or so. In 1900, demographers had the world's population at 1.6 billion, in 1950 it was about 2.5 billion, by 2000 it was more than 6 billion. Now, there are about 7.2 billion of us.

In recent years we've been adding about a billion people every 12 or 13 years or so. Precisely how many of us are here right now is also a matter of debate, depending on whom you consult: The United Nations offers a range of current population figures and trends, the U.S. Census Bureau has its own estimate, and the Population Reference Bureau also tracks us.

The new UN study out this week projects that the world's population growth may not stop any time soon. That is a reversal from estimates done five years ago, when demographers—people who study population trends—were projecting that by 2045, world population likely would reach about 9 billion and begin to level off soon after.

But now, the UN researchers who published these new projections in the journal *Science* say that a flattening of population growth is not going to happen soon without rapid fertility declines—or a reduction in the number of children per mother—in most parts of sub-Saharan Africa that are still experiencing rapid population growth. As Rob Kunzig wrote for *National Geographic*, the new study estimates that "there's an 80 percent chance . . . that the actual number of people in 2100 will be somewhere between 9.6 and 12.3 billion."

A History of Debates Over Population

In a famous 1798 essay, the Reverend Thomas Malthus proposed that human population would grow more rapidly than our ability to grow food, and that eventually we would starve.

He asserted that the population would grow geometrically—1, 2, 4, 8, 16, 32—and that food production

Dimick, Dennis, "As World's Population Booms, Will Its Resources Be Enough For Us?" National Geographic, September 20, 2014. Copyright ©2014 National Geographic Society. Reprinted by permission. All rights reserved.

would increase only arithmetically—1, 2, 3, 4, 5, 6. So food production would not keep up with our expanding appetites. You might imagine Malthus' scenario on geometric population growth as being like compound interest: A couple have two children and those children each produce two children. Those four children produce two children each to make eight, and those eight children each have their own two kids, leaving 16 kids in that generation. But worldwide, the current median fertility rate is about 2.5, (or five children between two couples), so, like compound interest, the population numbers can rise even faster.

Even though more than 800 million people worldwide don't have enough to eat now, the mass starvation Mathus envisioned hasn't happened. This is primarily because advances in agriculture—including improved plant breeding and the use of chemical fertilizers—have kept global harvests increasing fast enough to mostly keep up with demand. Still, researchers such as Jeffrey Sachs and Paul Ehrlich continue to worry that Malthus eventually might be right.

Ehrlich, a Stanford University population biologist, wrote a 1968 bestseller called *The Population Bomb*, which warned of mass starvation in the 1970s and 1980s because of overpopulation. Even though he drastically missed that forecast, he continues to argue that humanity is heading for calamity. Ehrlich says the key issue now is not just the number of people on Earth, but a dramatic rise in our recent consumption of natural resources, which Elizabeth Kolbert explored in 2011 in an article called "The Anthropocene—The Age of Man."

As part of this human-dominated era, the past half century also has been referred to as a period of "Great Acceleration" by Will Steffen at The International Geosphere-Biosphere Program. Besides a near tripling of human population since the end of World War II, our presence has been marked by a dramatic increase in human activity—the damming of rivers, soaring water use, expansion of cropland, increased use of irrigation and fertilizers, a loss of forests, and more motor vehicles. There also has been a sharp rise in the use of coal, oil, and gas, and a rapid increase in the atmosphere of methane and carbon dioxide, greenhouse gases that result from changes in land use and the burning of such fuels.

Measuring Our Rising Impact

As a result of this massive expansion of our presence on Earth, scientists Ehrlich, John Holdren, and Barry Commoner in the early 1970s devised a formula to measure our rising impact, called IPAT, in which (I)mpact equals (P)opulation multiplied by (A)ffluence multiplied by (T)echnology.

The IPAT formula, they said, can help us realize that our cumulative impact on the planet is not just in population numbers, but also in the increasing amount of natural resources each person uses. . . . [T]rise in our cumulative impact since 1950—rising population combined with our expanding demand for resources—has been profound.

IPAT is a useful reminder that population, consumption, and technology all help shape our environmental impact, but it shouldn't be taken too literally. University of California ecologist John Harte has said that IPAT ". . . conveys the notion that population is a linear multiplier. . . . In reality, population plays a much more dynamic and complex role in shaping environmental quality."

One of our biggest impacts is agriculture. Whether we can grow enough food sustainably for an expanding world population also presents an urgent challenge, and this becomes only more so in light of these new population projections. Where will food for an additional 2 to 3 billion people come from when we are already barely keeping up with 7 billion? Such questions underpin a 2014 *National Geographic* series on the future of food.

As climate change damages crop yields and extreme weather disrupts harvests, growing enough food for our expanding population has become what The 2014 World Food Prize Symposium calls "the greatest challenge in human history."

Population's Structure: Fertility, Mortality, and Migration

Population is not just about numbers of people. Demographers typically focus on three dimensions—fertility, mortality, and migration—when examining population trends. Fertility examines how many children a woman bears in her lifetime, mortality looks at how long we live, and migration focuses on where we live and move. Each of these population qualities influences the nature of our presence and impact across the planet.

The newly reported higher world population projections result from continuing high fertility in sub-Saharan Africa. The median number of children per woman in the region remains at 4.6, well above both the global mean of 2.5 and the replacement level of 2.1. Since 1970, a global decline in fertility—from about 5 children per woman to about 2.5—has occurred across most of the world: Fewer babies have been born, family size has shrunk, and population growth has slowed. In the United States, fertility is now slightly below replacement level.

Reducing fertility is essential if future population growth is to be reined in. Cynthia Gorney wrote about the dramatic story of declining Brazilian fertility as part of *National Geographic's 7* Billion series. Average family size dropped from 6.3 children to 1.9 children per woman over two generations in Brazil, the result of improving education for girls, more career opportunities, and the increased availability of contraception.

Mortality—or birth rates versus death rates—and migration (where we live and move) also affect the structure of population. Living longer can cause a region's population to increase even if birth rates remain constant. Youthful nations in the Middle East and Africa, where there are more young people than old, struggle to provide sufficient land, food, water, housing, education, and employment for young people. Besides the search for a life with more opportunity elsewhere, migration also is driven by the need to escape political disruption or declining environmental conditions such as chronic drought and food shortages.

A paradox of lower fertility and reduced population growth rates is that as education and affluence improves, consumption of natural resources increases per person. In other words, . . . as we get richer, each of us consumes more natural resources and energy, typically carbon-based fuels such as coal, oil, and gas. This can be seen in consumption patterns that include higher protein foods such as meat and dairy, more consumer goods, bigger houses, more vehicles, and more air travel.

When it comes to natural resources, studies indicate we are living beyond our means. An ongoing Global Footprint Network study says we now use the equivalent of 1.5 planets to provide the resources we use, and to absorb our waste. A study by the Stockholm Resilience Institute has identified a set of "nine planetary boundaries" for conditions in which we could live and thrive for generations, but it shows that we already have exceeded the institute's boundaries for biodiversity loss, nitrogen pollution, and climate change.

Those of us reading this article are among an elite crowd of Earthlings. We have reliable electricity, access to Internet-connected computers and phones, and time available to contemplate these issues.

About one-fifth of those on Earth still don't have access to reliable electricity. So as we debate population, things we take for granted—reliable lighting and cooking facilities, for example—remain beyond the reach of about 1.3 billion or more people. Lifting people from the darkness of energy poverty could help improve lives.

Improved education, especially for girls, is cited as a key driver of declining family size. Having light at night can become a gateway to better education for millions of young people and the realization that opportunities and choices besides bearing many children can await.

So when we debate population, it's important to also discuss the impact—the how we live—of the population equation. While new projections of even higher world population in the decades ahead are cause for concern, we should be equally concerned about—and be willing to address—the increasing effects of resource consumption and its waste.

Dennis Dimick is *National Geographic's* executive editor for the Environment.

Tom Bethell

NO

Population, Economy, and God

World population, once "exploding," is still increasing, and "momentum" ensures that it will do so for decades to come. But fertility rates have tumbled. In Europe every country has fallen below replacement level. Some governments, especially France's, are beginning to use financial incentives to restore fertility rates but the effort, if generous enough to work—by paying women to have a third child—could bankrupt the welfare state.

In rich countries, a total fertility rate of 2.1 babies per woman is needed if population is to remain stable. But in the European Union as a whole the rate is down to 1.5. Germany is at 1.4, and Italy, Spain, and Greece are at 1.3. The fertility rate in France is now 2.0, or close to replacement. But the uneasy question is whether this is due to subsidies or to the growing Muslim population.

All over the world, with a few anomalies, there is a strong inverse correlation between GDP per capita and babies per family. It's a paradox, because wealthier people can obviously afford lots of children. But very predictably they have fewer. Hong Kong (1.02), Singapore, and Taiwan are three of the richest countries in the world, and three of the four lowest in total fertility. The countries with the highest fertility rates are Mali (7.4), Niger, and Uganda. Guess how low they are on the wealth chart.

Here's a news item. Carl Djerassi, one of the inventors of the birth control pill, recently deplored the sharp decline of total fertility in Austria (1.4), the country of his birth. A Catholic news story seized on that and reported that one of the pill's inventors had said the pill had caused a "demographic catastrophe." Austria's leading Catholic, Cardinal Schönborn, said the Vatican had predicted 40 years ago that the pill would promote a dramatic fall in birth rates.

Djerassi, 85, an emeritus professor of chemistry at Stanford, did warn of a catastrophe and he said that Austria should admit more immigrants. But he denied that people have smaller families "because of the availability of birth control." They do so "for personal, economic, cultural, and other reasons," of which "changes in the status of women" was the most important. Japan has an even worse demographic problem, he said, "yet the pill was only legalized there in 1999 and is still not used widely." (Japan's fertility rate is 1.22.) (In fact, if the pill and abortion really were illegal more children surely would be born, if only because unintentional pregnancies would come to term.)

Austrian families who had decided against children wanted "to enjoy their schnitzels while leaving the rest of the world to get on with it," Djerassi also said. That may have rankled because the country had just put his face on a postage stamp.

So what is causing these dramatic declines? It's under way in many countries outside Europe too. In Mexico, fertility has moved down close to replacement level—having been as high as six babies per woman in the 1970s.

Obviously economic growth has been the dominant factor but there are other considerations.

Young couples hardly read Paul Ehrlich before deciding whether to have children, but scaremongering authors have played a key role in creating our anti-natalist mood. Books warning of a (then) newfangled emergency, the "population explosion," began appearing soon after World War II. Consider *Road to Survival* (1948), by William Vogt, or *People! Challenge to Survival*, by the same author. An anti-people fanatic before his time, Vogt was hypnotized by the Malthusian doctrine that population growth would overtake the food supply. That would lead to a war of all against all. Paul Ehrlich projected that the 1980s would see massive die-offs from starvation. (Obesity turned out to be the greater health threat.)

In that earlier period, the population controllers didn't feel they had to mince words. Vogt wrote in 1960 that "tens of thousands of children born every year in the United States should, solely for their own sakes, never have seen the light of day. . . . There are hundreds of thousands of others, technically legitimate since their parents have engaged in some sort of marriage ritual, but whose birth is as much of a crime against them as it is against the bastards."

At a time when the world population still had not reached 3 billion—today it is 6.7 billion—Vogt thought "drastic measures are inescapable." He warned of "mounting

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population pressures in the Soviet Union," where, by the century's end, "there may be 300 million Russians." It was time for them "to begin control of one of the most powerful causes of war—overpopulation."

Note: the population of Russia by 2000 was 145 million; today it is 141 million. (Fertility rate: 1.4.)

Population alarmists have long enjoyed the freedom to project their fears onto whatever cause is uppermost in the progressive mind. Then it was war. Today it is the environment, which, we are told, human beings are ruining. This will be shown to have been as false as the earlier warnings, but not before our environmental scares have done much harm to a fragile economy (at the rate things are going with Obama). All previous scares were based on faulty premises, and the latest one, based on "science," will be no different.

I believe that two interacting factors shape population growth or decline: economic prosperity and belief in God. As to the first, there is no doubt that rising material prosperity discourages additional children. Fewer infants die; large families are no longer needed to support older parents. The welfare state—which only rich countries can afford—has greatly compounded this effect. When people believe that the government will take care of them, pay their pensions and treat their maladies, children do seem less essential.

A rise in prosperity also encourages people to think that they can dispense with God. Religion diminishes when wealth increases—that's my theory. But with a twist that I shall come to. Wealth generates independence, including independence from God, or (if you will) Providence. God is gradually forgotten, then assumed not to exist. This will tend to drive childbearing down even further. Hedonism will become predominant. Remember, Jesus warned that it's the rich, not the poor, who are at spiritual hazard.

The legalization of abortion reflected the decline of religious faith in America, but it must also have led others to conclude that God was no longer to be feared. That's why I don't quite believe Djerassi when he tries to disassociate the pill from fertility. The ready availability of the pill told society at large that sex without consequences was perfectly acceptable. Then, by degrees, that self-indulgent view became an anti-natalist worldview.

It became so ingrained that many people now think it obvious. Sex became a "free" pastime as long as it was restricted to consenting adults. Furthermore, anyone who questioned that premise risked denunciation as a bigot.

The U.S. has been seen as the great stumbling block to any theory linking prosperity, lack of faith, and low fertility. Prosperity here has been high, and overall fertility is at replacement. But I am wary of this version of American exceptionalism. How much lower would U.S. fertility fall without the influx of Latino immigrants and their many offspring? Nicholas Eberstadt, a demographer at AEI, tells me that Mexican immigrants now actually have a higher fertility rate in the U.S. than they do in Mexico. (Maybe because they come to American hospitals for free medical care?)

I wonder also if religious vitality here is what it's cracked up to be. Surely it has weakened considerably. A recent survey by Trinity College in Hartford, funded by the Lilly Endowment, showed that the percentage of Americans identifying themselves as Christian dropped to 76 percent from 86 percent in 1990; those with "no" religion, 8.2 percent of the population in 1990, are now 15 percent.

As a social force, the U.S. Catholic bishops have withered away to a shocking extent. Hollywood once respected and feared their opinion. Today, the most highly placed of these bishops are unwilling to publicly rebuke proabortion politicians who call themselves Catholic, even when they give scandal by receiving Communion in public. How the mitered have fallen. They daren't challenge the rich and powerful.

But there is another factor. Calling yourself a Christian when the pollster phones imposes no cost and selfreported piety may well be inflated. We have to distinguish between mere self-labelers and actual churchgoers. And beyond that there are groups with intense religious belief who retain the morale to ignore the surrounding materialism and keep on having children.

The ultra-Orthodox in Israel are the best example. Other Jewish congregations may go to synagogue, but they have children at perhaps one-third the ultra-Orthodox rate. At about seven or eight children per family, theirs is one of the highest fertility rates in the world. And they don't permit birth control—Carl Djerassi, please note. In the U.S. Orthodox Jews again far outbreed their more secular sisters.

The Mormons are also distinctive. Utah, about twothirds Mormon, has the highest fertility rate (2.63 in 2006) among the 50 states; Vermont has the lowest (1.69). In the recent Trinity Survey, Northern New England is now "the least religious section of the country." Vermont is the least religious state; 34 percent of residents say they have "no religion." So minimal faith and low fertility are demonstrably linked. Mormon fertility is declining, to be sure, and I recognize that I am flirting with a circular argument: deciding which groups are the most fervent by looking at their birth rates.

Then there's the Muslim concern. It's hard to avoid concluding that the lost Christian zeal has been

appropriated by Islam. In the U.S., Muslims have doubled since 1990 (from a low base, to 0.6% of the population). The rise of Islam suggests that the meager European fertility rates would be even lower if Muslims had not contributed disproportionately to European childbearing.

It's hard to pin down the numbers, though. Fertility in France has risen, but Nick Eberstadt tells me that the French government won't reveal how many of these babies are born to Muslim parents. "They treat it as a state secret," he said. In other countries such as Switzerland, where lots of guest workers are employed, the fertility rate would be much lower than it already is (1.44) were it not for the numerous offspring of those guest workers.

When a population is not replacing itself, the welfare state creates its own hazard. Lots of new workers are needed to support the retirees. Germany's low fertility will require an annual immigration of 200,000 just to maintain the current population. Where will they come from? Many arrive from Turkey, where the fertility rate has also declined (to about 2.0). But not as far as it has declined among native Germans. So the concern is that in the welfare states of Europe, believing Muslims are slowly replacing the low-morale, low-fertility, materialistic non-believers who once formed a Christian majority.

I could summarize the argument with this overstatement: The intelligentsia stopped believing in God in the 19th century. In the 20th it tried to build a new society, man without God. It failed. Then came a new twist. Man stopped believing in himself. He saw himself as a mere polluter—a blot on the landscape. Theologians tell us that creatures cannot exist without the support of God. A corollary may be that societies cannot long endure without being sustained by a *belief* in God.

Tom Bethell is a senior editor of *The American Spectator*.

EXPLORING THE ISSUE

Do We Have a Population Problem?

Critical Thinking and Reflection

1. Is it possible to have too many people on Earth?
2. What is wrong with the statement that there is no population problem because all of Earth's human population could fit inside the state of Texas?
3. What does population have to do with sustainability?
4. What is more important for long-term survival of the human species—population control or belief in God?

Is There Common Ground?

The essayists for this issue agree that human population continues to grow and that long-term human survival (or sustainability) matters. They disagree on the best way to achieve long-term human survival.

1. Does quality of life seem likely to suffer more with a declining population or a growing population?
2. What are the key features of "quality of life"? (One good place to start your research is www.foe.co.uk/community/tools/isew/)
3. How might we determine what the Earth's carrying capacity for human beings really is?
4. What is the influence (if any) of religious faith on carrying capacity?

Additional Resources

Matthew Connolly, *Fatal Misconception: The Struggle to Control World Population* (Belknap Press, 2010).

Jonathan A. Foley, "Can We Feed the World & Sustain the Planet?" *Scientific American* (November 2011).

David Malakoff, "Are More People Necessarily a Problem?" *Science* (July 29, 2011).

Fred Pearce, *The Coming Population Crash: And Our Planet's Surprising Future* (Beacon, 2010).

Julia Whitty, "The Last Taboo," *Mother Jones* (May–June 2010).

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www.facingthefuture.org/

Population Reference Bureau

www.prb.org/

United States & World Population Clocks

www.census.gov/main/www/popclock.html

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ISSUE

Will Hydraulic Fracturing (Fracking) Negatively Affect Human Health and the Environment?

YES: John Rumpler, from "Fracking: Pro and Con," *Tufts Now* (2013)

NO: Bruce McKenzie Everett, from "Fracking: Pro and Con," *Tufts Now* (2013)

Learning Outcomes

After reading this issue, you will be able to:

- Understand the environmental impact of fracking.
- Discuss the health concerns of fracking.
- Discuss the impact that fracking has on the economy and oil dependence.

ISSUE SUMMARY

YES: Environmentalist and senior attorney for Environment America John Rumpler argues that fracking is not worth the damage to health and the environment.

NO: Energy researcher and Adjunct Professor Bruce McKenzie Everett claims fracking provides substantial economic benefits and its health and environmental problems are relatively small.

Hydraulic fracturing, or fracking, is a process that extracts natural gas from rock beneath the earth's surface. Many rocks such as shale, sandstones, and limestone deep in the ground contain natural gas, which was formed as dead organisms in the rock decomposed. This gas can be released and captured at the surface for energy use when the rocks in which it is trapped are drilled. To enhance the flow of released gas, the rocks are broken apart, or fractured. In the past, drillers often detonated small explosions in the wells to increase flow. Starting about 70 years ago, oil and gas drilling companies began fracking rock by pumping pressurized water into it.

Since the 1940s, about 1 million American wells have been fracked. The majority of these are vertical wells that tap into porous sandstone or limestone. During the past 20 years, however, energy companies have had the ability to capture the gas still stuck in the original shale source. Fracking shale is achieved by drilling level wells that expand from their vertical well shafts along thin, horizontal shale layers. Drilling of this nature has allowed engineers to insert millions of gallons of high-pressure water directly into layers of shale to generate the fractures that release the gas. Chemicals added to the water dissolve minerals, destroy bacteria that might block the well, and add sand to hold open the fractures.

While the process offers inexpensive energy options, there are many opponents of the process. The majority of these opponents concentrate on possible local environmental outcomes. Some of these consequences are specific to the more recent fracking technology, while others are more relevant to the overall processes of natural gas extraction. The mixture of chemicals used in fracking processes includes acids, detergents, and toxins that are not controlled by federal laws but can cause problems if they leak into drinking water. Since the 1990s, the fracking

process has employed increased amounts of chemical-laden water, injected at higher pressures. This causes the escape of methane gas into the environment out of gas wells, producing the real, though slight, chance of hazardous explosions. In general, water from all gas wells often returns to the surface' containing very low but measurable concentrations of radioactive elements and large salt concentration. Salts or brine can be harmful if not treated properly. Small earthquakes have been triggered in rare instances after the introduction of brine into deep wells.

Along with these regional consequences, natural gas extraction has worldwide environmental impacts, because both the methane gas that is retrieved through extraction and the carbon dioxide liberated during methane burning are greenhouse gases that add to global climate change. Recent fracking technologies foster the extraction of higher quantities of gas, which adds more to climate change than former natural gas extraction processes.

In Pennsylvania, there has been rapid development of the Marcellus Shale, a geological formation that could contain nearly 500 trillion cubic feet of gas. This amount of natural gas is considered enough to power all U.S. residences for 50 years at current rates of usage. The experience in Pennsylvania with water and soil contamination, however, is of concern. Shale gas in Pennsylvania is accessed at depths of thousands of feet, while water for drinking is removed from depths of only hundreds of feet. Nowhere in the state have fracking chemicals injected at depth been shown to contaminate drinking water. In a research study of 200 private drinking water wells in Pennsylvania fracking regions, water quality was the same before and shortly after drilling in all wells except one. Unfortunately, however, trucking and storage accidents have spilled fracking chemicals and brines, leading to contamination of water and soils that required decontamination. Also, many gas companies do not consistently reveal the composition of all fracking and drilling compounds, which makes it challenging to check for injected chemicals in surface and groundwater.

Instances of methane leaking into aquifers in regions where shale-gas drilling is ongoing have also occurred in Pennsylvania. A portion of this gas is "drift gas" that forms naturally in deposits left behind by the most recent glaciers. But occasionally methane seeps out of gas wells because linings are not structurally sound, which occurs in about 1–2 percent of the wells. The linings can be repaired to address these slight leaks, and the risk of such methane leaks could further decrease if linings were designed specifically for each geological area.

The disposal of shale gas salt/brine was originally addressed in Pennsylvania by permitting the gas industry to use municipal water treatment plants that were not equipped to manage the toxic substances. In 2011 new regulations were enacted and Pennsylvania energy companies now recycle 90 percent of the salty water by using it to frack more shale.

Overall, the experience of fracking in Pennsylvania has led to industry changes that alleviate the impact of drilling and fracking on the local environment. Though the natural gas produced by fracking does increase greenhouse gases in the atmosphere through leakage during gas extraction and carbon dioxide emitted during burning, it does hold an important environmental benefit over coal mining. Gases released from shale contain 50 percent of the carbon dioxide per unit of energy as does coal, and coal burning also releases metals such as mercury into the atmosphere that ultimately settle back into water and soil.

In Europe, there is currently an increase in reliance on coal while discouraging or restricting fracking. If Americans are going to get our energy needs mostly from fossil fuels, banning fracking while mining and burning coal appears to be a negative environmental trade-off. The question is: Should Europe and the United States support fracking or prohibit it? Many regional effects of fracking and drilling have received a lot of press but actually generated a small amount of problems, while others are more serious. Economic interests in the short term favor fracking. The Pennsylvania experience caused natural gas prices to fall and jobs were created both directly in the gas industry and indirectly as local and national economies benefit from reduced energy costs. If, however, fracked gas shifts efforts to develop cleaner energy sources without decreasing reliance on coal, the consequences of accelerated global climate change will occur.

Overall, there are both advantages and disadvantages to hydraulic fracturing. The environmental impact could be lessened as well as the risk to human health via water contamination and the increase in greenhouse gases by utilizing lessons learned from Pennsylvania. In the YES and NO selections, John Rumpler argues that we are making a mistake in thinking that fracking is worth the damage to the environment. Bruce McKenzie Everett disagrees and claims that fracking offers substantial economic benefits and its problems are relatively minor compared to the advantages.

YES

John Rumpler

Fracking: Pro and Con

For some Americans, it is our energy dreams come true. To others, it is an environmental nightmare. Ever since a new drilling technology, called hydraulic fracturing or fracking, made it possible to extract natural gas from shale deposits about a mile underground, a new gold rush has been under way.

While fracking has created jobs and contributed to record-low natural gas prices, it comes with another kind of potential cost: risks to our environment and health that some say are far too high.

The fracking process begins with a bore hole drilled some 6,000 feet below ground, cutting through many geological layers and aquifers, which tend to be no more than a few hundred feet below the surface. The shaft is then lined with steel and cement casing. Monitors above ground signal when drilling should shift horizontally, boring sideways to pierce long running sections of shale bedrock.

Millions of gallons of water mixed with sand and chemicals are then blasted into the bedrock, the pressure creating cracks that release trapped natural gas from the shale. The gas and water mixture then flows back up to the surface, where the gas is separated from the water. While most of the water stays in the well bore, up to 20 percent is either reused for more fracking or injected into disposal wells thousands of feet underground.

The wellpad and related infrastructure take up to eight to nine acres of land, according to the Nature Conservancy. Fracking is currently occurring in Texas and Pennsylvania, the two largest gas-producing states, as well as in North Dakota, Arkansas, California, Colorado and New Mexico. And the oil and gas industry is eager to expand its fracking operations into New York, North Carolina, Maryland and Illinois. . . .

John Rumpler . . . argues that we are making a mistake in thinking that fracking is worth the damage to the environment. He is a senior attorney at Environment America, which is leading a national effort to restrict, regulate and ultimately end the practice of fracking. He has fought for clean air in Ohio and advocated to protect the Great Lakes and the Chesapeake Bay. This fall he is teaching the Experimental College course Fracked Out: Understanding the New Gas Rush.

Tufts Now: Is Fracking Safe?

. . .

John Rumpler: Fracking presents a staggering array of threats to our environment and our health. These range from contaminating drinking water and making families living near well sites sick to turning pristine landscapes into industrial wastelands. There are air pollution problems and earthquakes from the deep-well injections of the wastewater into the gas-producing shale, as well as significant global warming emissions.

When the industry says there has not been a single case of groundwater contamination, they mean there is not a verified instance of the fracking fluid traveling up through a mile of bedrock into the water table. What they cannot dispute is that fluid and chemicals have leached into groundwater at 421 fracking waste pits in New Mexico. What they cannot dispute is that a peer-reviewed study by Duke University linked methane in people's drinking water wells to gas-drilling operations in surrounding areas. What they cannot dispute is a University of Colorado study published earlier this year documenting that people living within a half mile of fracking and other gas-drilling operations have an increased risk of health problems, including cancer from benzene emissions.

Are There Sufficient Regulations Now in Place to Ensure Safety?

Rumpler: Is it conceivable to imagine regulatory fixes for all the various problems caused by fracking? Theoretically, perhaps. But imagine trying to implement the hundreds of different rules and regulations at thousands of oil- and gas-drilling sites across the country, and you realize there is no practical likelihood that fracking will ever be made safe.

Rumpler, John. "Fracking: Con," from Tufts Now, 2013. Used by permission of Tufts University.

And there are consequences that we don't even know how to regulate yet. Geologists are just beginning to think about the long-term implications of drilling down a mile and then drilling horizontally through shale rock for another mile. We don't know what happens to the structural integrity of that bedrock once you withdraw all of the gas and liquid from it. No one has the definitive answer. There's been some recent modeling that indicates a loss of stability that goes all the way up to the water table. The U.S. Geological Survey took a look at some earthquakes that occurred in the vicinity of Youngstown, Ohio, in proximity to deep-well fracking. They found that the seismic activity was most certainly manmade—and there was no manmade activity in the area except fracking.

So when you look at the whole picture—from contaminated wells to health problems to earthquakes—[you quickly come] to see that the best defense against fracking is no fracking at all.

As for the current state of regulations, it is worth noting that fracking is exempt from key provisions of our nation's environmental laws, including the Safe Drinking Water Act, the Clean Air Act, the Clean Water Act, and the Resource Conservation Recovery Act. The reason we have national environmental laws is to prevent states from "racing to the bottom of the barrel" to appease powerful industries. . . .

What Are the Economic Benefits of Fracking?

. . .

Rumpler: First of all, any discussion of economics needs to deal with costs as well as benefits. This fall, our *Costs of Fracking* report detailed the dollars drained by dirty drilling—from property damage to health-care costs to roads ruined by heavy machinery. In Pennsylvania's last extractive boom, the state was stuck with a $5 billion bill to clean up pollution from abandoned mines. What happens when the fracking boom is long gone and communities are stuck with the bill?

In contrast, energy efficiency, wind and solar all provide great economic benefits with no hidden costs. But the oversupply of cheap gas is driving wind and solar out of the market. It's long been fashionable to say that natural gas can be a bridge to clean energy, but in fact it's become a wall to clean energy, because investors don't want to put money into wind and solar when gas is so cheap.

What Danger to the Environment or the Economy Is Caused by the Billions of Gallons of Fresh Water Each Year That Are "Consumed" by Fracking Operations? How Might This Affect the Economic Benefits or Environmental Concerns?

. . .

Rumpler: Each fracking well uses millions of gallons of water. And that water mostly winds up either staying down in the well or being injected deep into the earth as wastewater. So unlike other sectors that use much more water by volume, including agriculture and residential, the water used for fracking is mostly consumed, gone to us for ever.

Does the Current Low Price of Natural Gas Affect Fracking or Conventional Gas Production?

Rumpler: Take a look at Chesapeake Energy, which is one of the biggest fracking operators out there. By the accounts of some analysts, they are massively overextended, with too much land and too many drilling leases. With the price at $2 per million BTU, there was some risk that Chesapeake could at some point lose enough money to risk bankruptcy—and then what would happen to these communities where fracking has taken place? If not Chesapeake, it will be another driller—probably one of the smaller ones—that goes under, and the communities will be left holding the bag. And gas companies don't tell landowners leasing property that oil and gas operations are violations of most standard mortgage agreements, because that is not a risk that the lender is willing to take. Likewise, homeowners' insurance may not cover damages from fracking. Nationwide insurance announced just this summer that their standard policy does not cover damage from fracking. That tells you something. The risk analysts who did the math figured out this is not a safety winner for them. . . .

What If We Halted All Fracking Right Now?

. . .

Rumpler: There's a difference between not starting fracking in new areas and halting it everywhere immediately. If we don't open new places to fracking in New York, Pennsylvania and Texas—just stop where we are now—the

impact would be minimal. As Bruce notes, there is so much gas being produced right now that some gas companies are aggressively seeking export licenses, because they want to get rid of the excess and earn a profit. We don't need it to fill energy needs.

In North Dakota they are flaring off the gas, just wasting it into the air. If we need this gas to meet our energy needs, then they should make gas flaring a federal crime and should immediately ban any and all exports of natural gas. The industry would fight tooth and nail against this.

Until we know more, the risks to our health and environment far outweigh any possible benefit to our economy or energy future.

John Rumpler is an environmentalist and attorney.

Bruce McKenzie Everett

NO

Fracking: Pro and Con

For some Americans, it is our energy dreams come true. To others, it is an environmental nightmare. Ever since a new drilling technology, called hydraulic fracturing or fracking, made it possible to extract natural gas from shale deposits about a mile underground, a new gold rush has been under way. . . .

The fracking process begins with a bore hole drilled some 6,000 feet below ground, cutting through many geological layers and aquifers, which tend to be no more than a few hundred feet below the surface. The shaft is then lined with steel and cement casing. Monitors above ground signal when drilling should shift horizontally, boring sideways to pierce long running sections of shale bedrock.

Millions of gallons of water mixed with sand and chemicals are then blasted into the bedrock, the pressure creating cracks that release trapped natural gas from the shale. The gas and water mixture then flows back up to the surface, where the gas is separated from the water. While most of the water stays in the well bore, up to 20 percent is either reused for more fracking or injected into disposal wells thousands of feet underground. . . .

Bruce McKenzie Everett, F70, F72, F80, an adjunct associate professor of international business at the Fletcher School, says fracking provides substantial economic benefits and its problems are relatively small compared to those benefits. He worked at the U.S. Department of Energy from 1974 to 1980 before beginning a 20-year career with ExxonMobil, working in Hong Kong, the Middle East, Africa and Latin America. His research has included gas-to-liquid conversion technology as well as the economics of oil, gas and coal production and use. . . .

Tufts Now: Is Fracking Safe?

Bruce McKenzie Everett: Nothing in the world is entirely safe, but by the standards of industrial activity in the United States, fracking is very, very safe. Think about the airline industry. Lots of things can go wrong with airplanes, but we work very hard to make sure they don't, and as a result, flying is one of the safest activities we've got. Now, that does not mean that things can't happen. It just means that with proper attention, mistakes can be kept to an extremely low level.

The question about fracking that gets the most attention is contamination of drinking water. Aquifers, the underground rivers that provide our drinking water, are about 100 to 200 feet below the surface. The gas-producing shale rock formations tend to be 5,000 to 6,000 feet below the surface. So you need to make sure that the well you drill to pump the water and chemicals through the shale to fracture it and release the gas is sealed properly, and that's not a hard thing to do. . . .

Are There Sufficient Regulations Now in Place to Ensure Safety?

. . .

Everett: There are a lot of regulations currently in place. The question is whether they should be done at the federal or state level. For example, the state government of Pennsylvania understood that the economic activity from fracking could be very, very positive for the state. So they worked with the fracking industry and enacted numerous regulations to try to make sure that two things happened: that they eliminated the dangers to the extent that you can, but that they allowed fracking sites to go forward because the jobs and tax revenue were so positive.

In New York State, they've put a moratorium on fracking, basically saying, "I don't know what to do, so I'll study it and see what happens." I think that's unfortunate, because most of New York is quite economically depressed, and they are denying people economic opportunities.

I have taken a very strong position that it's a bad idea to federalize regulations. If you leave it at the state level, local governments will tend to strike a balance between the economic benefits and the environmental safety issues. If it is left to the federal government, you'll have the same problem you had with the Keystone oil pipeline: people who are not impacted, who will not enjoy the economic benefits, will be allowed to come in and say they don't like it.

Everett, Bruce McKenzie. "Fracking: Pro," Tufts Now, 2013. Used by permission of Tufts University.

What Are the Economic Benefits of Fracking?

Everett: It creates jobs, but that's not the most important way to measure its economic effect. The cost of everything we purchase has an energy component to it, either in its manufacture or its shipping or its packaging. So it is very important to the economy to have energy prices that are relatively low.

Natural gas has become incredibly inexpensive, way beyond what we ever thought possible. We're talking about prices going from $10 or $11 per thousand cubic feet 10 years ago down to $3.77 now, because the supply that has been released by this innovative fracking production technique is just so large. It is a simple consequence of supply and demand. These natural gas prices are the equivalent of oil prices falling to $21 per barrel from their current $86 per-barrel price. . . .

What Danger to the Environment or the Economy Is Caused by the Billions of Gallons of Fresh Water Each Year That Are "Consumed" By Fracking Operations? How Might This Affect the Economic Benefits or Environmental Concerns?

Everett: The water from fracking can be handled in one of several ways: storing, reinjecting and recycling. The real problem we have is that water is not properly priced. As a landowner, you are entitled to draw water from underground aquifers at whatever rate you wish, even if that water is only flowing through your land. We therefore tend to treat water as a free good. Putting a price on it or, alternatively, finding a way to assign property rights would probably fix this problem. As a third alternative, government could regulate it. In any case, it's a solvable problem. . . .

Does the Current Low Price of Natural Gas Affect Fracking or Conventional Gas Production?

. . .

Everett: The price of natural gas has now gotten so low that some are saying they can't produce it economically—but this is a *good* thing for all of us, because it will force them to explore new markets and uses. The United States has an open economy and is a large global trading player. Americans pay the global price for the many things we buy and sell, and energy is one. There are several directions that natural gas production, both fracking and conventional, can take.

One is that people just stop producing it at the current rates, and the price returns to a more stable level and just stays there, likely at the $10-to-$12-dollar level of a decade ago. We could also start exporting. The world price for natural gas is $15 to $16 per thousand cubic feet. By selling it on the global market, that money would come into the U.S. economy. It would require some expensive infrastructure to support it, but the profit margin is so huge, some $12 per thousand cubic feet, that it would be well worth it and a positive impact on our economy.

We could also begin to shut down older coal-fired power plants and replace them with cleaner natural gas plants, and natural gas could find its way into the transportation sector. With engine modifications, it could be used as fuel for cars, or it could be used to produce the battery power for electric cars.

What If We Halted All Fracking Right Now?

Everett: If we stopped right now, or placed a moratorium on new fracking, the price of natural gas would go up to the previous $10 to $11, or worse case, to the global price of $15 to $16. This means electricity prices would go up, heating prices would go up, and we'd lose the economic activity the industry is generating through jobs and lower prices. Basically we would be giving up an opportunity.

Hazards can be controlled through solid regulations that include monitoring and quick responses to problems that arise. Any risks are outweighed by economic benefits. It's not even a close call. . . .

Bruce McKenzie Everett is an energy researcher and adjunct professor.

EXPLORING THE ISSUE

Will Hydraulic Fracturing (Fracking) Negatively Affect Human Health and the Environment?

Critical Thinking and Reflection

1. What are the major economic advantages to fracking?
2. What impact will fracking have on the quality of drinking water?
3. What effect will increased fracking have on the incentive to develop other cleaner energy sources including renewable?
4. What are the health implications of fracking?

Is There Common Ground?

In the spring of 2008, filmmaker Josh Fox received an offer from a natural gas company to lease his family's land in Milanville, Pennsylvania, for $100,000 to drill for gas. Fox then set out to see how communities are being affected in the West where a natural gas drilling boom has been underway for the last 10 years. He spent time with people in their homes and on their land as they relayed their stories of natural gas drilling in Colorado, Wyoming, Utah, and Texas. Fox spoke with residents who experienced a variety of chronic health problems they claim were directly traceable to contamination of their air, of their water wells, or of surface water. In some cases, the residents report that they obtained a court injunction or settlement monies from gas companies to replace the affected water supplies with drinkable water.

The result of Fox's research was the documentary film *Gasland*. During the making of the film, Fox connected with scientists, politicians, and gas industry executives and ultimately found himself in Washington as a subcommittee was discussing the Fracturing Responsibility and Awareness of Chemicals Act, a proposed exemption for hydraulic fracturing from the Safe Drinking Water Act. While the film has both supporters and critics, it did bring publicity to the issues surrounding fracking and raised the question: Is the process safe for the environment and human health and do the economic benefits outweigh any actual or potential problems?

As the United States and Europe seek ways to reduce energy costs and reliance on imported fuels, fracking may be an opportunity to achieve these goals. It's a domestic resource that can be extracted around the country and offers jobs and cheaper energy. On the other hand, there are concerns that the fracking processes needed to extract gas may contaminate ground and surface water with toxic chemicals that could impact health and the environment.

Additional Resources

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www.americanrivers.org/fracking

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ISSUE

Should the United States Eliminate Its Dependence on Foreign Oil?

YES: Clifford Krauss and Eric Lipton, from "The Energy Rush; U.S. Inches Toward Goal of Energy Independence," *The New York Times* (March 22, 2012)

NO: Paul Roberts, from "The Seven Myths of Energy Independence: Why Forging a Sustainable Energy Future Is Dependent on Foreign Oil," *Mother Jones* (May/June 2008)

Learning Outcomes

After reading this issue, you should be able to:

- Discuss the history of the political debate about energy independence in the United States.
- Distinguish energy independence from energy security.
- Discuss the argument that energy independence would further U.S. national security.
- Assess the ability of the United States to end its use of foreign oil.
- Discuss the viability of alternative forms of energy to replace oil.

ISSUE SUMMARY

YES: Clifford Krauss and Eric Lipton, correspondents with *The New York Times*, argue that eliminating U.S. dependence on foreign oil is feasible and should be a strategic priority for the United States. Recent technological advances that enable the expanded use of U.S. oil reserves and reduce the energy consumption of consumer goods make it possible for the United States to produce enough energy domestically to meet its needs.

NO: Paul Roberts, a freelance journalist, argues that the idea that the United States can obtain independence from foreign oil is an illusion that distracts politicians from the more practical long-term goal of energy security. Energy security is the pursuit of energy sources that are "reliable and reasonably affordable, that can be deployed quickly and easily, yet are also safe and politically and environmentally sustainable." To obtain energy security, the United States should continue to draw on both domestic and foreign energy sources.

The debate in the United States over the pursuit of energy independence began almost four decades ago. In response to the Organization of Petroleum Exporting Countries (OPEC) oil embargo in 1973, President Richard Nixon declared that energy independence had become a vital national security concern. Despite continued rhetorical support for this goal from every one of Nixon's successors as President, U.S. oil imports increased from 35 percent in 1973 to 60 percent in the late 2000s. They subsequently dropped to 45 percent by 2011, but this was largely due to declining demand caused by the 2009 recession (Mullaney, 2012). In the 2012 election year, the debate continued through the campaign speeches given by incumbent Democratic President Barack Obama and his Republican challenger, Governor Mitt Romney. While both candidates recommended different policy solutions, both argued that achieving independence from foreign oil was achievable. While the debate remains lively, in some sense both sides are backing an untested proposition since many policies that could promote the achievement of energy independence have not been implemented due to other, overriding domestic and national security concerns.

Energy independence is defined here as the ability of the United States to produce all of its oil needs domestically. Oil drives, literally, much of what powers industrialized society because the economy largely relies upon oil, in the form of gasoline and diesel fuel, to move goods to domestic and foreign markets and workers to and from their jobs. As of 2010, oil was used to meet over 90 percent of U.S. transportation requirements (U.S. Energy Information Administration, 2010). Yet, uncertainty exists about the size of existing global oil reserves and the ability of these reserves to meet expanding global demand for oil

(Jordan et al., 2009). Developing countries, such as China and India, are rapidly increasing their use of oil as they industrialize, placing upward pressure on oil prices. As their economies grow, domestic producers in these countries require more oil to transport goods to market and consumers need more oil to fuel the cars they are increasingly able to afford. Given these factors, "most oil economists agree that the global economy will run through the remaining deposits of easy oil much faster [than in the past] . . ., resulting in abruptly higher and unpredictable price levels" (Doran, 2008).

Efforts are being made to meet this growing demand through exploration and the development of new oil fields and methods of extraction. Yet, oil remains a relatively inelastic good in the short term, meaning that there are no close substitutes available now to replace its use. Despite ongoing research, a viable alternative to oil has not yet been found to fuel the transportation sector. In addition to the difficulty of finding short-term substitutes, there is also concern about sufficient availability of oil over the longer term. While new fields and production methods allow for greater oil production, costs of production are increasing because much of this oil is harder to exploit because it is located deeper and/or further off-shore. Many of the newly discovered fields also contain oil that is of lesser quality, and therefore requires more complex refining to bring it to market (Campbell and Laherrere, 1998).

In addition to the demand-side pressures on the global oil market that stem from economic growth in emerging economies, geopolitical developments can also increase the economic and security costs to the United States of foreign oil dependence. Most recently, political turmoil in the Middle East in the wake of the Arab Spring and international tensions over a potential Iranian nuclear weapons program have placed further upward pressure on oil prices and created new uncertainties about supply. Especially in a global oil market made tighter by increases in demand, a disruption in the flow of oil from the Persian Gulf could have a significant economic impact. Though the dynamics would be different than those that created by the supply-side shocks that arose from the Arab–Israeli War of 1973 and the Iranian Revolution in 1979, the resulting negative impact of new instability in the oil market could be significant. In the 1970s, oil shortages in select countries contributed to periods of painfully high inflation, high interest rates, and several years of recession (Hubbard and O'Brien, 2010). Some analysts fear that the impact of a new energy crisis now could be even more extreme.

Advocates of breaking U.S. dependence on foreign oil argue that oil imports from the Persian Gulf and other unstable regions create an "American dependence on foreign oil [that] at current levels . . . [constitutes] a grave security and economic risk" (Hakes, 2008). From a security perspective, energy independence advocates argue that U.S. reliance on volatile and unfriendly countries for oil fosters political instability and strengthens U.S. adversaries. For example, oil exports may provide resources that give hostile governments the ability to remain in power and enable states like Iran to fund violent proxy groups abroad like Hamas or Hezbollah that may contribute to political instability. From an economic perspective, U.S. reliance on foreign oil is a risk since potential adversaries could use this dependence to gain leverage against the United States. If, for example, countries were to use oil today as a weapon by withholding its flow to the world market—like OPEC did in the 1970s—the United States could face high inflation and reduced economic activity caused by higher oil prices. Given its slow recovery from the 2009 recession, such a development could push the United States into another recession. Instead of accepting these risks, if the United States were to further develop domestic oil sources, the United States would lessen its dependence on potential future adversaries. It is with this logic in mind that Governor Sarah Palin's 2008 campaign slogan, "Drill, baby, drill," which advocated access to all reserves in the United States—including those containing oil that requires more refining and those that are in environmentally sensitive areas—still resonates with some (Doran, 2008).

As an alternative to breaking foreign dependence on oil by developing and extracting more oil from domestic sources, some insist that the United States should focus on transitioning to domestically generated alternative sources of energy. This group of proponents, which includes former oilman T. Boone Pickens, wants to shift the American energy infrastructure toward one based largely on natural gas and augmented by wind. Pickens estimates that "building new wind generation facilities, conserving energy, and increasing the use of our natural gas resources [could] replace more than one-third of our foreign oil imports in ten years." He also makes an economic argument to support his push away from oil, claiming that developing the vast natural gas reserves in the United States and building a natural gas-based infrastructure would generate jobs at home, while enabling the use of a relatively secure energy source to fuel U.S. homes and industry. As a further benefit, the United States could also generate revenue by exporting excess domestic production (Pickens, 2012).

Critics of energy independence question the feasibility of rejecting foreign oil and trying to rely solely on domestic sources, and they also question whether the benefits of attaining energy independence would outweigh the costs. They argue that to sustain economic growth and improve living standards, the United States will require continued access to oil from all possible sources. As long as other countries continue to produce oil at relatively low costs compared to the cost to produce a barrel of U.S. oil—and as long as they maintain large reserves—Saudi Arabia and other major producers will remain dominant (Cordesman and Al-Rodhan, 2006). Rather than resisting this practical reality, the United States should encourage the production of a relatively stable supply of petroleum

into the near future. Over the long term, the United States should work with OPEC countries and other major producers to prolong the production value of their remaining reserves, while focusing U.S. industries on the production of oil-based products such as gasoline, plastics, and chemicals for domestic and export markets.

Critics of the pursuit of energy independence also believe the United States should recognize the global nature of the market for oil and act accordingly. It is incorrect to believe that "oil markets are structurally fragmented so that the ramifications of disruptions are localized, rather than felt globally, and that by arranging regional supply agreements, a nation can immunize itself against a disruption elsewhere in the world" (Griffin, 2009). In reality, any disruption to the oil supply affects the price consumers in every country must pay. Focusing on independence from foreign oil distracts the U.S. government from the policies it really needs that would supplement the workings of the global oil market rather than work fruitlessly against it. Such policies would support research and development on alternative energy sources and facilitate the construction of the distribution infrastructure needed for U.S. consumers and industry to use these new forms of energy.

In addressing the question of whether or not the United States should pursue energy independence by eliminating U.S. dependence on foreign oil, Clifford Krauss and Eric Lipton say YES. They argue that the United States does not have to worry about domestic oil depletion. This is due to supply-side and demand-side technological improvements. On the supply side, fears about oil depletion have been overblown because the oil industry has found, due to new technological advances, new reserves and ways to extract more from existing reserves. On the demand side, the domestic demand for oil has decreased because consumer goods and automobile manufacturers have developed much more energy-efficient products. Kraus and Lipton believe that continued supply- and demand-side technological advances will allow the United States to become energy independent.

In countering with a NO answer, Paul Roberts says that the United States should not make the elimination of dependence on foreign oil a strategic priority. Instead, the real goal of U.S. policy should be energy security. Roberts discusses seven myths and addresses each one to explain how the United States should build a strategy that enables access to reliable, accessible, and safe energy from a wide variety of sources—at home and abroad.

YES

Clifford Krauss and Eric Lipton

The Energy Rush; U.S. Inches Toward Goal of Energy Independence

The desolate stretch of West Texas desert known as the Permian Basin is still the lonely domain of scurrying roadrunners by day and howling coyotes by night. But the roar of scores of new oil rigs and the distinctive acrid fumes of drilling equipment are unmistakable signs that crude is gushing again.

And not just here. Across the country, the oil and gas industry is vastly increasing production, reversing two decades of decline. Using new technology and spurred by rising oil prices since the mid-2000s, the industry is extracting millions of barrels more a week, from the deepest waters of the Gulf of Mexico to the prairies of North Dakota.

At the same time, Americans are pumping significantly less gasoline. While that is partly a result of the recession and higher gasoline prices, people are also driving fewer miles and replacing older cars with more fuel-efficient vehicles at a greater clip, federal data show.

Taken together, the increasing production and declining consumption have unexpectedly brought the United States markedly closer to a goal that has tantalized presidents since Richard Nixon: independence from foreign energy sources, a milestone that could reconfigure American foreign policy, the economy and more. In 2011, the country imported just 45 percent of the liquid fuels it used, down from a record high of 60 percent in 2005.

"There is no question that many national security policy makers will believe they have much more flexibility and will think about the world differently if the United States is importing a lot less oil," said Michael A. Levi, an energy and environmental senior fellow at the Council on Foreign Relations. "For decades, consumption rose, production fell and imports increased, and now every one of those trends is going the other way."

How the country made this turnabout is a story of industry-friendly policies started by President Bush and largely continued by President Obama—many over the objections of environmental advocates—as well as technological advances that have allowed the extraction of oil and gas once considered too difficult and too expensive to reach. But mainly it is a story of the complex economics of energy, which sometimes seems to operate by its own rules of supply and demand.

With gasoline prices now approaching record highs and politicians mud-wrestling about the causes and solutions, the effects of the longer-term rise in production can be difficult to see.

Simple economics suggests that if the nation is producing more energy, prices should be falling. But crude oil—and gasoline and diesel made from it—are global commodities whose prices are affected by factors around the world. Supply disruptions in Africa, the political standoff with Iran and rising demand from a recovering world economy all are contributing to the current spike in global oil prices, offsetting the impact of the increased domestic supply.

But the domestic trends are unmistakable. Not only has the United States reduced oil imports from members of the Organization of the Petroleum Exporting Countries by more than 20 percent in the last three years, it has become a net exporter of refined petroleum products like gasoline for the first time since the Truman presidency. The natural gas industry, which less than a decade ago feared running out of domestic gas, is suddenly dealing with a glut so vast that import facilities are applying for licenses to export gas to Europe and Asia.

National oil production, which declined steadily to 4.95 million barrels a day in 2008 from 9.6 million in 1970, has risen over the last four years to nearly 5.7 million barrels a day. The Energy Department projects that daily output could reach nearly seven million barrels by 2020. Some experts think it could eventually hit 10 million barrels—which would put the United States in the same league as Saudi Arabia.

This surge is hardly without consequences. Some areas of intense drilling activity, including northeastern Utah and central Wyoming, have experienced air quality problems. The drilling technique called hydraulic fracturing, or fracking, which uses highly pressurized water, sand and chemical lubricants that help force more oil and gas from rock formations, has also been blamed for wastewater problems. Wildlife experts also warn that expanded drilling is threatening habitats of rare or endangered species.

Greater energy independence is "a prize that has long been eyed by oil insiders and policy strategists that can bring many economic and national security benefits," said Jay Hakes, a senior official at the Energy Department

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during the Clinton administration. "But we will have to work through the environmental issues, which are a definite challenge."

The increased production of fossil fuels is a far cry from the energy plans President Obama articulated as a candidate in 2008. Then, he promoted policies to help combat global warming, including vast investments in renewable energy and a cap-and-trade system for carbon emissions that would have discouraged the use of fossil fuels.

More recently, with gasoline prices rising and another election looming, Mr. Obama has struck a different chord. He has opened new federal lands and waters to drilling, trumpeted increases in oil and gas production and de-emphasized the challenges of climate change. On Thursday, he said he supported expedited construction of the southern portion of the proposed Keystone XL oil pipeline from Canada.

Mr. Obama's current policy has alarmed many environmental advocates who say he has failed to adequately address the environmental threats of expanded drilling and the use of fossil fuels. He also has not silenced critics, including Republicans and oil executives, who accuse him of preventing drilling on millions of acres off the Atlantic and Pacific Coasts and on federal land, unduly delaying the decision on the full Keystone project and diverting scarce federal resources to pie-in-the-sky alternative energy programs.

Just as the production increase was largely driven by rising oil prices, the trend could reverse if the global economy were to slow. Even so, much of the industry is thrilled at the prospects.

"To not be concerned with where our oil is going to come from is probably the biggest home run for the country in a hundred years," said Scott D. Sheffield, chief executive of Pioneer Natural Resources, which is operating in West Texas. "It sort of reminds me of the industrial revolution in coal, which allowed us to have some of the cheapest energy in the world and drove our economy in the late 1800s and 1900s."

The Foundation Is Laid

For as long as roughnecks have worked the Permian Basin—made famous during World War II as the fuel pump that powered the Allies—they have mostly focused on relatively shallow zones of easily accessible, oil-soaked sandstone and silt. But after 80 years of pumping, those regions were running dry.

So in 2003, Jim Henry, a West Texas oilman, tried a bold experiment. Borrowing an idea from a fellow engineer, his team at Henry Petroleum drilled deep into a hard limestone formation using a refinement of fracking. By blasting millions of gallons of water into the limestone, they created tiny fissures that allowed oil to break free, a technique that had previously been successful in extracting gas from shale.

The test produced 150 barrels of oil a day, three times more than normal. "We knew we had the biggest discovery in over 50 years in the Permian Basin," Mr. Henry recalled.

There was just one problem: At $30 a barrel, the price of oil was about half of what was needed to make drilling that deep really profitable.

So the renaissance of the Permian—and the domestic oil industry—would have to wait.

But the drillers in Texas had important allies in Washington. President Bush grew up in Midland and spent 11 years as a West Texas oilman, albeit without much success, before entering politics. Vice President Dick Cheney had been chief executive of the oil field contractor Halliburton. The Bush administration worked from the start on finding ways to unlock the nation's energy reserves and reverse decades of declining output, with Mr. Cheney leading a White House energy task force that met in secret with top oil executives.

"Ramping up production was a high priority," said Gale Norton, a member of the task force and the secretary of the Interior at the time. "We hated being at the mercy of other countries, and we were determined to change that."

The task force's work helped produce the Energy Policy Act of 2005, which set rules that contributed to the current surge. It prohibited the Environmental Protection Agency from regulating fracking under the Safe Drinking Water Act, eliminating a potential impediment to wide use of the technique. The legislation also offered the industry billions of dollars in new tax breaks to help independent producers recoup some drilling costs even when a well came up dry.

Separately, the Interior Department was granted the power to issue drilling permits on millions of acres of federal lands without extensive environmental impact studies for individual projects, addressing industry complaints about the glacial pace of approvals. That new power has been used at least 8,400 times, mostly in Wyoming, Utah and New Mexico, representing a quarter of all permits issued on federal land in the last six federal fiscal years.

The Bush administration also opened large swaths of the Gulf of Mexico and the waters off Alaska to exploration, granting lease deals that required companies to pay only a tiny share of their profits to the government.

These measures primed the pump for the burst in drilling that began once oil prices started rising sharply in 2005 and 2006. With the world economy humming—and China, India and other developing nations posting astonishing growth—demand for oil began outpacing the easily accessible supplies.

By 2008, daily global oil consumption surged to 86 million barrels, up nearly 20 percent from the decade before. In July of that year, the price of oil reached its highest level since World War II, topping $145 a barrel (equivalent to more than $151 a barrel in today's dollars).

Oil reserves once too difficult and expensive to extract—including Mr. Henry's limestone fields—had become more attractive.

If money was the motivation, fracking became the favored means of extraction.

While fracking itself had been around for years, natural gas drillers in the 1980s and 1990s began combining high-pressure fracking with drilling wells horizontally, not just vertically. They found it unlocked gas from layers of shale previously seen as near worthless.

By 2001, fracking took off around Fort Worth and Dallas, eventually reaching under schools, airports and inner-city neighborhoods. Companies began buying drilling rights across vast shale fields in a variety of states. By 2008, the country was awash in natural gas.

Fracking for oil, which is made of larger molecules than natural gas, took longer to develop. But eventually, it opened new oil fields in North Dakota, South Texas, Kansas, Wyoming, Colorado and, most recently, Ohio.

Meanwhile, technological advances were making deeper oil drilling possible in the Gulf of Mexico. New imaging and seismic technology allowed engineers to predict the location and size of reservoirs once obscured by thick layers of salt. And drill bits made of superstrong alloys were developed to withstand the hot temperatures and high pressures deep under the seabed.

As the industry's confidence—and profits—grew, so did criticism. Amid concerns about global warming and gasoline prices that averaged a record $4.11 a gallon in July 2008 ($4.30 in today's dollars), President Obama campaigned on a pledge to shift toward renewable energy and away from fossil fuels.

His administration initially canceled some oil and gas leases on federal land awarded during the Bush administration and required more environmental review. But in a world where crucial oil suppliers like Venezuela and Libya were unstable and high energy prices could be a drag on a weak economy, he soon acted to promote more drilling. Despite a drilling hiatus after the 2010 explosion of the Deepwater Horizon in the Gulf of Mexico, which killed 11 rig workers and spilled millions of barrels of crude oil into the ocean, he has proposed expansion of oil production both on land and offshore. He is now moving toward approving drilling off the coast of Alaska.

"Our dependence on foreign oil is down because of policies put in place by our administration, but also our predecessor's administration," Mr. Obama said during a campaign appearance in March, a few weeks after opening 38 million more acres in the gulf for oil and gas exploration. "And whoever succeeds me is going to have to keep it up."

An American Oil Boom

The last time the Permian Basin oil fields enjoyed a boom—nearly three decades ago—Rolls-Royce opened a showroom in the desert, Champagne was poured from cowboy boots, and the local airport could not accommodate all the Learjets taking off for Las Vegas on weekends.

But when crude prices fell in the mid-1980s, oil companies pulled out and the Rolls dealership was replaced by a tortilla factory. The only thriving business was done by bankruptcy lawyers and auctioneers helping to unload used Ferraris, empty homes and useless rigs.

"One day we were rolling in oil," recalled Jim Foreman, the general manager of the Midland BMW dealership, "and the next day geologists were flipping burgers at McDonald's."

The burger-flipping days are definitely over. Today, more than 475 rigs—roughly a quarter of all rigs operating in the United States—are smashing through tight rocks across the Permian in West Texas and southeastern New Mexico. Those areas are already producing nearly a million barrels a day, or 17 percent more than two years ago. By decade's end, that daily total could easily double, oil executives say, roughly equaling the total output of Nigeria.

"We're having a revolution," said G. Steven Farris, chief executive of Apache Corporation, one of the basin's most active producers. "And we're just scratching the surface."

It is a revolution that is returning investments to the United States. Over several decades, Pioneer Natural Resources had taken roughly $1 billion earned in Texas oil fields and drilled in Africa, South America and elsewhere. But in the last five years, the company sold $2 billion of overseas assets and reinvested in Texas shale fields.

"Political risk was increasing internationally," said Mr. Sheffield, Pioneer's chief executive, and domestically, he was encouraged to see "the shale technology progressing."

Pioneer's rising fortunes can be seen on a 10,000-acre field known as the Giddings Estate, a forsaken stretch inhabited by straggly coyotes, rabbits, rattlesnakes and cows that forage for grass between the sagebrush. When Pioneer bought it in 2005, the field's hundred mostly broken-down wells were producing a total of 50 barrels a day. "It was a diamond in the rough," said Robert Hillger, who manages it for Pioneer.

Mr. Hillger and his colleagues have brought an array of new tools to bear at Giddings. Computer programs simulate well designs, minimizing trial and error. Advanced fiber optics allow senior engineers and geologists at headquarters more than 300 miles away to monitor progress and remotely direct the drill bit. Subterranean microphones help identify fissures in the rock to plan subsequent drilling.

Today, the Giddings field is pumping 7,000 barrels a day, and Pioneer expects to hit 25,000 barrels a day by 2017.

The newfound wealth is spreading beyond the fields. In nearby towns, petroleum companies are buying so many pickup trucks that dealers are leasing parking lots the size of city blocks to stock their inventory. Housing is in such short supply that drillers are importing contractors from Houston and hotels are leased out before they are even built.

Two new office buildings are going up in Midland, a city of just over 110,000 people, the first in 30 years, while the total value of downtown real estate has jumped 50 percent since 2008. With virtually no unemployment, restaurants cannot find enough servers. Local truck drivers are making six-figure salaries.

"Anybody who comes in with a driver's license and a Social Security card, I'll give him a chance," said Rusty Allred, owner of Rusty's Oilfield Service Company.

If there is a loser in this boom, it is the environment. Water experts say aquifers in the desert area could run dry if fracking continues expanding, and oil executives concede they need to reduce water consumption. Yet environmental concerns, from polluted air to greenhouse gas emissions, have gained little traction in the Permian Basin or other outposts of the energy expansion.

On the front lines in opposition is Jay Lininger, a 36-year-old ecologist who drives through the Permian in an old Toyota Tacoma with a hard hat tilted on his head and a federal land map at the ready.

A former national park firefighter, he says he is now battling a wildfire of a different sort—the oil industry.

Nationally, environmentalists have challenged drilling with mixed results. Efforts to stop or slow fracking have succeeded in New York State and some localities in other states, but it is spreading across the country.

In the Permian, Mr. Lininger said, few people openly object to the foul-smelling air of the oil fields. Ranchers are more than happy to sell what water they have to the oil companies for fracking.

Mr. Lininger and his group are trying to slow the expansion of drilling by appealing to the United States Fish and Wildlife Service to protect several animal species, including the five-inch dunes sagebrush lizard.

"It's a pathetic little lizard in an ugly desert, but life needs to be protected," he said. "Every day we burn fossil fuel makes it harder for our planet to recover from our energy addiction."

Mr. Lininger said the oil and ranching industries had already destroyed or fragmented 40 percent of the lizard's habitat, and 60 percent of what is left is under lease for oil and gas development.

The wildlife agency proposed listing the lizard as endangered in 2010 and was expected to decide last December, but Congressional representatives from the oil patch won a delay. Oil companies are working on a voluntary program to locate new drilling so it will not disturb the lizard habitat.

But for Mr. Lininger's group, the Center for Biological Diversity, that is far from sufficient.

Brendan Cummings, senior counsel of the center, said protecting the lizard was part of a broader effort to keep drilling from harming animals, including polar bears, walruses and bowhead whales in the Alaskan Arctic and dwarf sea horses and sea turtles in the Gulf of Mexico.

"When you are dealing with fossil fuels, things will always go wrong," Mr. Cummings said. "There will always be spills, there will always be pollution. Those impacts compound the fragmentation that occurs and render these habitats into sacrifice areas."

A Turn Toward Efficiency

If the Permian Basin exemplifies the rise in production, car-obsessed San Diego is a prime example of the other big factor in the decline in the nation's reliance on foreign oil.

Just since 2007, consumption of all liquid fuels in the United States, including diesel, jet fuel and heating oil, has dropped by about 9 percent, according to the Energy Department. Gasoline use fell 6 to 12 percent, estimated Tom Kloza, chief oil analyst at the Oil Price Information Service.

Although Southern California's love affair with muscle cars and the open road persists, driving habits have changed in subtle but important ways.

Take Tory Girten, who works as an emergency medical technician and part-time lifeguard in the San Diego area. He switched from driving a Ford minivan to a decidedly smaller and more fuel-efficient Dodge Caliber. Fed up with high gasoline prices, he also moved twice recently to be closer to the city center, cutting his daily commute considerably—a hint of the shift taking place in certain metropolitan areas as city centers become more popular while growth in far-out suburbs slows.

"I would rather pay a little more monthly for rent than for just filling up my tank with gas," he said, after pulling into a local gas station to fill up.

Mr. Girten is one of millions of Americans who have downsized. S.U.V.'s accounted for 18 percent of new-car sales in 2002, but only 7 percent in 2010.

The surge in gasoline prices nationwide—they are already at a record level for this time of year—has contributed to the shift toward more fuel-efficient cars. But a bigger factor is rising federal fuel economy standards. After a long freeze, the miles-per-gallon mandate has been increased several times in recent years, with the Obama administration now pushing automakers to hit 54.5 m.p.g. by 2025.

As Americans replace their older cars—they have bought an average of 1.25 million new cars and light trucks a month this year—new technologies mean they usually end up with a more efficient vehicle, even if they buy a model of similar size and power.

California has long pushed further and faster toward efficiency than the rest of the country. It has combated often severe air pollution by mandating cleaner-burning cars, including all-electric vehicles, and prodded Washington to increase the fuel efficiency standards.

Thousands of school buses, trash trucks, tractor-trailers and street sweepers and public transit buses in the state run on natural gas, which is cheaper than gasoline and burns more cleanly. That switch cuts the consumption of foreign oil, as does the corn-based ethanol that is now mixed into gasoline as a result of federal mandates.

Longer-term social and economic factors are also reducing miles driven—like the rise in Internet shopping and telecommuting and the tendency of baby boomers to drive less as they age. The recession has also contributed, as job losses have meant fewer daily commutes and falling home prices have allowed some people to afford to move closer to work.

The trend of lower consumption, when combined with higher energy production, has profound implications, said Bill White, former deputy energy secretary in the Clinton administration and former mayor of Houston.

"Energy independence has always been a race between depletion and technologies to produce more and use energy more efficiently," he said. "Depletion was winning for decades, and now technology is starting to overtake its lead."

Clifford Krauss is a correspondent for the *New York Times*. Previously, he worked as a foreign correspondent for *The Wall Street Journal* and was the Edward R. Murrow fellow at the Council on Foreign Relations.

Eric Lipton is a correspondent for the *New York Times*. Previously, he worked at *The Washington Post* and *The Hartford Courant*.

Paul Roberts

NO

The Seven Myths of Energy Independence: Why Forging a Sustainable Energy Future Is Dependent on Foreign Oil

Myth #1
Energy Independence Is Good

On February 1, 2006, Prince Turki al-Faisal, Saudi Arabia's ambassador to Washington, arrived at the White House in a state of agitation. The night before, in his State of the Union address, President Bush had declared the United States to be "addicted to oil, which is often imported from unstable parts of the world." He had announced plans to "break this addiction" by developing alternatives—including a multibillion-dollar subsidized ramp-up of biofuels—and had boldly stated that by 2025, America could cut imports from Gulf states by three-quarters and "make our dependence on Middle Eastern oil a thing of the past." "I was taken aback," Prince Faisal later told cnn, "and I raised this point with government officials."

Two years on, anyone who's been to a gas station or a grocery store knows the prince had very little to worry about. Despite supposedly bold initiatives such as last year's Energy Independence and Security Act, America is no freer from foreign oil: Since 2006, imports have remained steady at about 13 million barrels every day, while the price for each of those barrels has jumped by $30. And though federal efforts to encourage biofuel production have significantly boosted output, our heavily subsidized ethanol refiners now use so much corn (closing in on a third of the total crop) that prices for all grains have soared, sparking inflation here at home and food riots abroad.

Okay, so maybe ethanol's critics are right, and turning food into fuel isn't the smartest way to wean ourselves from imported oil. But the deeper lesson here isn't that Washington backed the wrong weapon in the war for energy independence, but that most policymakers—and Americans generally—still think "energy independence" is a goal we can, or should, achieve. Nine in ten voters say the country is too dependent on foreign crude. Every major presidential hopeful formulated some kind of strategy for energy liberation (Rudy Giuliani unveiled his at a NASCAR race), and between 2001 and 2006 the number of media references to "energy independence" jumped by a factor of eight.

And on the surface, the argument seems solid. Imported oil, some 60 percent of the oil we use, exposes our economy and politics to stresses halfway around the world (bin Laden calls it "the umbilical cord and lifeline of the crusader community"). It also increases our already massive trade imbalance, which must be corrected by ever-greater federal borrowing, and funnels tens of billions of dollars to the likes of Saudi Arabia, Russia, and Venezuela—countries that are unfriendly and, in some cases, actively anti-American. What's not to like about energy independence?

In a word, everything. Despite its immense appeal, energy independence is a nonstarter—a populist charade masquerading as energy strategy that's no more likely to succeed (and could be even more damaging) than it was when Nixon declared war on foreign oil in the 1970s. Not only have we no realistic substitute for the oceans of oil we import, but many of the crash programs being touted as a way to quickly develop oil replacements—"clean coal," for example, or biofuels—come at a substantial environmental and political cost. And even if we had good alternatives ready to deploy—a fleet of superefficient cars, say, or refineries churning out gobs of cheap hydrogen for fuel cells—we'd need decades, and great volumes of energy, including oil, to replace all the cars, pipelines, refineries, and other bits of the old oil infrastructure—and thus decades in which we'd depend on oil from our friends in Riyadh, Moscow, and Caracas. Paradoxically, to build the energy economy that we want, we're going to lean heavily on the energy economy that we have.

None of which is exactly news. Thoughtful observers have been trying to debunk energy independence since Nixon's time. And yet the dream refuses to die, in no small part because it offers political cover for a whole range of controversial initiatives. Ethanol refiners wave the banner of independence as they lobby Congress for massive subsidies. Likewise for electric utilities and coal producers as they push for clean coal and a nuclear renaissance. And it shouldn't surprise that some of the loudest proponents of energy liberation support plans to open the Arctic National Wildlife Refuge and other off-limits areas to oil drilling—despite the fact that such moves would, at

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best, cut imports by a few percentage points. In the doublespeak of today's energy lexicon, says Julia Bovey of the Natural Resources Defense Council, "'energy independence' has become code for 'drill it all.'"

Yet it isn't only the hacks for old energy and Archer Daniels Midland who are to blame. Some proponents of good alternatives like solar and wind have also harped on fears of foreign oil to advance their own sectors—even though many of these technologies are decades away from being meaningful oil replacements.

Put another way, the "debate" over energy independence is not only disingenuous, it's also a major distraction from the much more crucial question—namely, how we're going to build a secure and sustainable energy system. Because what America should be striving for isn't energy independence, but energy security—that is, access to energy sources that are reliable and reasonably affordable, that can be deployed quickly and easily, yet are also safe and politically and environmentally sustainable. And let's not sugarcoat it. Achieving real, lasting energy security is going to be extraordinarily hard, not only because of the scale of the endeavor, but because many of our assumptions about energy—about the speed with which new technologies can be rolled out, for example, or the role of markets—are woefully exaggerated. High oil prices alone won't cure this ill: We're burning more oil now than we were when crude sold for $25 a barrel. Nor will Silicon Valley utopianism: Thus far, most of the venture capital and innovation is flowing into status quo technologies such as biofuels. And while Americans have a proud history of inventing ourselves out of trouble, today's energy challenge is fundamentally different. Nearly every major energy innovation of the last century—from our cars to transmission lines—was itself built with cheap energy. By contrast, the next energy system will have to contend with larger populations and be constructed using far fewer resources and more expensive energy.

So it's hardly surprising that policymakers shy away from energy security and opt instead for the soothing platitudes of energy independence. But here's the rub: We don't have a choice. Energy security is nonnegotiable, a precondition for all security, like water or food or defense. Without it, we have no economy, no progress, no future. And to get it, we'll not only have to abandon the chimera of independence once and for all, but become the very thing that many of us have been taught to dread—unrepentant energy globalists.

Myth #2
Ethanol Will Set Us Free

What's wrong with energy independence? Let's start with the sheer physical enormity of replacing imports. Even if we limit the discussion to oil (and America buys boatloads of foreign natural gas, electricity, and even coal), the job is far more daunting than many liberationists—or environmentalists—want to believe.

If we distilled our entire corn crop into ethanol, the fuel produced would displace less than a sixth of the gasoline we currently guzzle, and other candidates, like hydrogen, are even more marginal. The challenge isn't simply quantity, but quality. Oil dominates the energy economy, and especially the transportation sector (which is 95 percent dependent on crude), in part because no other fuel offers the same combination of massive energy density and ease of handling. As author Richard Heinberg has observed, enough energy is contained in a single gallon of gasoline to replace 240 hours of human labor—considerably more than oil's likely rivals.

And because oil is relatively easy to produce, the energy "investment" needed to exploit that massive energy content is small. On average, an oil company burns the energy equivalent of 1 gallon of oil to produce 20 gallons of oil. In other words, oil's energy return on energy invested is quite high. By contrast, the return for oil's declared alternatives is quite low. For example, hydrogen, once considered a natural successor to oil, is so tricky to refine and handle that, by one study, a gallon of hydrogen contains nearly 25 percent less energy than was consumed producing it. As for ethanol's energy return, scientists are debating whether it's slightly positive or altogether negative.

Oil's qualities were unbeatable when it cost[s] $25 a barrel, and even at $100, it still has a critical advantage. Because it was generated ages ago and left for us in deep underground reservoirs, oil exists more or less in a state of economic isolation; that is, oil can be produced—pumped from the ground and refined—without directly impinging on other pieces of the world economy. By contrast, many of oil's competitors are intimately linked to that larger economy, in the sense that to make more of an alternative (ethanol, say) is to have less of something else (food, sustainably arable land).

Granted, oil's advantages will ultimately prove illusory due to its huge environmental costs and finite supply. But oil's decline won't, by itself, make alternatives any less problematic. Higher oil prices do encourage alternatives to expand, but in a world of finite resources, these expansions can come at substantial cost. Because good U.S. farmland is already scarce, every additional acre of corn for ethanol is an acre unavailable for soybeans, or wheat, whose prices then also rise—a ripple effect that affects meat, milk, soft drinks. . . . And for the record, to make enough corn ethanol to replace all our gasoline, we'd need to plant 71 percent of our farmland with fuel crops.

To be fair, ethanol can be produced in a way that is less disruptive to the food economy. Cellulosic ethanol, for example, is made from wood chips, crop detritus, and other organic waste. And in Brazil they make ethanol from sugarcane—a process a third as energy intensive as corn ethanol's. But cellulosic ethanol, though quite promising, is not yet commercial, while Brazilian ethanol is, well,

Brazilian: It's effectively barred from our market by a 54 cents per gallon tariff, which U.S. lawmakers defend on the grounds of energy independence, but which coincidently leaves corn ethanol, with its massive federal subsidy, as pretty much the only game in town. So much corn is now going to biofuel that the food and energy markets are effectively linked, an unprecedented coupling that not only disrupts global food security but also undermines corn ethanol's usefulness as an oil replacement.

The ripple effect of energy alternatives isn't confined to the economic sphere. As eager farmers have expanded their corn crops (U.S. farmers planted more acres in 2007 than anytime since World War II), they've tilled land not suited for intensive agriculture, exacerbating erosion and other environmental problems. Corn is also the most chemically intensive commercial grain crop; runoff attributable to the ethanol boom is causing oceanic dead zones and pesticide-laden groundwater.

Ethanol is an easy target, but the sad truth is that all of the ballyhooed alternatives carry at least some environmental or other external costs. Wind requires vast amounts of land; solar-cell manufacturing is chemically intensive. Nuclear energy is steeped in safety and security concerns. And although the United States could fuel its entire car fleet with a synthetic gasoline made from abundant coal, syngas is even more ecologically challenged than oil. Industry likes to trumpet potential technologies to capture and sequester coal's carbon dioxide, but the federal government has cut research funding. And as Severin Borenstein, an economist at the University of California-Berkeley, points out, even if we do find climate-friendly ways to turn coal into fuel, that's only one end of the process: "We're still going to be burning that fuel in cars and thus releasing all that CO_2 out the tailpipe."

Such problems drive home a critical flaw in the paradigm of energy independence—namely, that energy isn't a zero-sum game anymore. We can no longer look at the energy economy as a constellation of discrete sectors that can be manipulated separately; everything is tied together, which means that fixing a problem in one part of the system all but invariably creates a new problem, or a whole series of problems, somewhere else.

Myth #3
Conservation Is a "Personal Virtue"

By now it should be clear not only that energy independence is prohibitively costly, but that the saner objective—energy security—won't be met through some frantic search for a fuel to replace oil, but by finding ways to do without liquid fuel, most probably through massive increases in energy efficiency.

This isn't a popular idea with Dick Cheney, who before 9/11 famously said that "conservation may be a sign of personal virtue, but it is not a sufficient basis for a sound, comprehensive energy policy." Nor among traditional energy players, who desperately want to find something to sell us if oil becomes untenable—and don't really care if that something is hydrogen or ethanol or pig manure. But for the rest of us, the logic of conservation is pretty hard to argue with. Better energy efficiency is one of the fastest ways to reduce not only energy use, but pollution and greenhouse gas emissions: According to a new study by McKinsey & Company, if the United States aggressively adopted more efficient cars, factories, homes, and other infrastructure, our CO_2 emissions could be 28 percent below 2005 levels by 2030. And saving energy is almost always cheaper than making it: There is far more oil to be "found" in Detroit by designing more fuel-efficient cars than could ever be pumped out of ANWR. And because transportation is the biggest user of oil—accounting for 7 of every 10 barrels we burn—any significant reduction in the sector's appetite has massive ramifications. Even the relatively unambitious 2007 energy bill, which raises fuel-economy standards from 25 mpg to 35 mpg by 2020, would save 3.6 million barrels a day by 2030. And if we persuaded carmakers to switch to plug-in hybrids, we could cut our oil demand by a staggering 9 million barrels a day, about 70 percent of our current imports.

Such a shift would impose massive new demand on an electric grid already struggling to meet need, but plug-in hybrids actually stretch the grid's existing capacity. Charged up at night, when power demand (and thus prices) are low, plug-in hybrids exploit the grid's large volume of unused (and, until now, unusable) capacity. Such "load balancing" would let power companies run their plants around the clock (vastly more cost-effective than idling plants at night and revving them up at dawn); as important, it would substantially boost the grid's overall output. According to the Department of Energy, with such load balancing, America's existing power system could meet current power demands and generate enough additional electricity to run almost three-quarters of its car and light-truck fleet. That alone would be enough to drop oil consumption by 6.5 million barrels a day, or nearly a third of America's current demand.

Granted, this switch to electric-powered cars wouldn't be free. Seventy percent of America's electricity is made from high-carbon fuels like natural gas and especially coal, which is why the power sector emits 40 percent of all U.S. carbon emissions. Just 8.4 percent comes from renewable sources, and most of that is environmentally dubious hydroelectric; wind, solar, geothermal, and biomass together supply 2.4 percent, and despite rapid growth, their share of the power market will remain small for decades. Even so, an electric or plug-in hybrid fleet is still probably the most environmentally plausible path away from oil. Why? Because kilowatt for kilowatt, turning fossil fuels into electricity in massive centralized power plants and then putting that juice into car batteries is more efficient than burning fossil fuels directly in internal combustion engines, and thus generates fewer CO_2 emissions per mile traveled. (Our existing fleet generates

a third of America's CO_2 emissions.) The DOE found that replacing three-quarters of the U.S. fleet with plug-in hybrids would cut vehicle CO_2 emissions by 27 percent nationwide—40 percent or more if the country's power system were upgraded to match California's low-carbon grid. And once the new fleet is in place, there is nothing stopping us from upgrading our power sources to truly renewable systems.

Myth #4
We Can Go It Alone

Given America's reliance on imported oil, it seems safe to assume that if we succeeded in getting such dramatic reductions, whatever sacrifices we'd made would be more than compensated for by our new immunity to the nastiness of world oil markets. Let Saudi Arabia cut its production. Let Hugo Chávez sell his oil to China. Such maneuvers no longer matter to Fortress America.

And yet, no country can really hope to improve its energy security by acting alone. True, cutting our own oil use would bring great things here at home, everything from cleaner air and water to lower noise pollution. But we'd be surprised by how little our domestic reductions changed the rest of the world—or improved our overall energy security.

The first problem, once again, is the small-planet nature of energy. America may be the biggest user of oil, but the price we pay is determined by global demand, and demand is being driven largely by booming Asia, which is only too happy to burn any barrel we manage to conserve or replace. Second, any shift to alternatives or better efficiency will take years and perhaps decades to implement. The U.S. car fleet, for example, turns over at a rate of just eight percent a year. That's as fast as consumers can afford to buy new cars and manufacturers can afford to make them, which means that—even in a fantasy scenario where the cars were already designed, the factories retooled, and the workers retrained—it would still take 12 years to deploy a greener fleet.

Most forecasts fail to acknowledge how slowly such changes could actually occur. Sure, if the United States could cut its oil consumption overnight by 9 million barrels, or 6.5 million barrels, or even 3.6 million barrels, it would have a staggering impact on oil prices. But barring a global depression, demand won't ever drop so rapidly; instead, our demand reductions will be incremental and thus effectively canceled out by the expected demand growth in other, less efficiency-minded countries like China. Berkeley's Borenstein, for example, estimates that the 3.6 million barrels the United States would save by 2030 under the 2007 energy bill will be more than offset by growth in demand elsewhere. Put another way, we could all squeeze into smaller cars and still be paying $4 for a gallon of gasoline.

To be sure, energy security isn't defined solely by cheap energy, and in fact, a great many enviros and energy wonks like oil at $100 a barrel, as it seems to be the only thing keeping more of us from buying Hummers. But high prices are killing our other energy-security objectives. High prices mean that money is still flowing into rogue states. High oil prices also imply tight oil markets, prone to massive price swings that are painful for consumers and make it virtually impossible for companies and governments to forecast their future energy costs—and so correctly gauge how much to invest in next-generation energy technologies. And no matter how clean and carbon free the United States becomes, if China and India are still burning massive volumes of oil we haven't done much to improve long-term security of any kind.

The only way to achieve real energy security is to reengineer not just our energy economy but that of the entire world. Oil prices won't fall, evil regimes won't be bankrupt, and sustainability won't be possible—until global oil demand is slowed. And outside of an economic meltdown, the only way it can be is if the tools we deploy to improve our own security can be somehow exported to other countries, and especially developing countries.

Energy globalism doesn't mean that every new energy gadget or fuel we invent has to work in Beijing or Burkina Faso. It does, however, suggest that our current energy strategy, tailored primarily to our own markets and our own technical capabilities, will be next to useless in an energy economy that is increasingly global—and that at least some of our energy investments should be compatible with regions where natural resources are strained, governments are poor, and consumers don't have access to home-equity lines of credit.

Myth #5
Some Geek in Silicon Valley Will Fix the Problem

So, what kinds of technologies would qualify under this more global strategy? Although corn and even cane ethanol are dubious—arable land in most of the developing world is already far too scarce—cellulosic ethanol has definite potential. Plug-in hybrids are probably too expensive for most Third World consumers, but have possibilities in the megacities of Asia and Latin America.

In the near term, however, the most practical energy export will be efficiency. China is so woefully inefficient that its economy uses 4.5 times as much energy as the United States for every dollar of output. This disparity explains why China is the world's second-biggest energy guzzler, but also why selling China more efficient technologies—cars, to be sure, but also better designs for houses, buildings, and industrial processes—could have a huge impact on global energy use and emissions.

As a bonus, such exports would likely be highly profitable. Japan, whose economy is nine times as energy efficient as China's, sees enormous economic and diplomatic opportunities selling its expertise to the Chinese,

and America could tap into those opportunities as well—provided technologies with export potential get the kind of R&D support they need. Yet this isn't assured. You may have read that the volume of venture capital flowing into energy-technology companies is at a record high. But much of this capital is flowing into known technologies with rapid and assured payoffs—such as corn ethanol—instead of more speculative, but potentially more useful, technologies like cellulosic ethanol.

Once upon a time, America compensated for investor reluctance with gobs of federal money. But though President Bush routinely promises to spend more on alternative energy, little new money has appeared; federal spending on solar research, for example, is well short of that in the Clinton years, and the $148 million Bush pledged for solar back in 2006 was, in inflation-adjusted terms, less than half of what we spent annually in the 1970s. Other technologies suffer as well. Senator Richard Lugar, an Indiana Republican who has long argued for a global approach to energy security, notes that despite Bush's stated support for cellulosic ethanol, the Energy Department's "glacial implementation" of R&D loan guarantees has turned off potential investors. "The project is moving forward," Lugar says, "but critical time was lost."

Myth #6
Cut Demand and the Rest Will Follow

Given America's tectonic pace toward energy security, the time has come for tough love. Most credible proposals call for some kind of energy or carbon tax. Such a tax would have two critical effects. It would keep the cost of oil high and thus discourage demand, as it has in Europe, and it would generate substantial revenues that could be used to fund research into alternatives, for example, or tax credits and other incentives to invest in the new energy technologies.

To be sure, higher fuel taxes, never popular with voters, would be even less so with gasoline prices already so high. Indeed, many energy wonks are still bitter that President Bush didn't advocate for a fuel tax or other demand-reduction measures in the aftermath of 9/11, when oil prices were relatively low and Americans were in the mood for sacrifice. Bush "could have gotten any set of energy measures passed after 9/11 if he had had an open and honest dialogue with America about how bad things were," says Edward Morse, an energy market analyst and former State Department energy official.

Instead, Bush urged Americans to . . . go shopping. Seven years later, with oil prices soaring and the economy hurting, swaying the electorate will take a politician who is politically courageous, extraordinarily articulate—and willing to dispense with the sweet nothings of energy independence.

And higher energy taxes are just the first dose of bitter medicine America needs to swallow if it wants real energy security. For no matter how aggressively the United States cuts oil demand both at home and abroad, it will be years and perhaps decades before any meaningful decline. The 12-year fleet-replacement scenario outlined above, for example, assumes that efficient new cars are being mass-produced worldwide and that adequate new volumes of electricity can be brought online as the fleet expands—assumptions that at present are wildly invalid. A more reasonable timetable is probably on the order of 20 years.

During this transition away from oil, we will still need lots and lots (and lots) of oil to fuel what remains of the oil-burning fleet. If over those 20 years global oil demand were to fall from the current 86 million barrels a day to, say, 40 million barrels a day, we'd still need an average of 63 million barrels a day, for a total of 459 billion barrels, or almost half as much oil as we've used since the dawn of humankind.

And here we come to two key points. First, because the transition will require so much old energy, we may get only one chance: If we find ourselves in 2028 having backed the wrong clusters of technologies or policies, and are still too dependent on oil, there may not be enough crude left in the ground to fuel a second try. Second, even if we do back the right technologies, the United States and the world's other big importers will still need far too much oil to avoid dealing with countries like Iran, Saudi Arabia, and Russia—no matter how abhorrent we find their politics.

In one of the many paradoxes of the new energy order, more energy security means less energy independence.

Myth #7
Once Bush Is Gone, Change Will Come

No presidential candidate has indicated he or she will raise energy taxes or sit down in oil talks with Tehran. All have ties to a self-interested energy sector, be it coal, ethanol, or nukes. And even after the election, energy security is so complex and requires such hard choices that any president, and most members of Congress, will be sorely tempted to skirt the issue in the tried and true manner, by pushing for a far more palatable "energy independence." As Senator Lugar so choicely put it, "The president will have advisers who will be whispering cautions about the risks of committing the prestige of any administration to aggressive energy goals. Those advisers will say with some credibility that a president can appear forward-looking on energy with a few carefully chosen initiatives and occasional optimistic rhetoric promoting alternative sources. They will say that the voting public's overwhelming energy concern is high prices for gasoline and home heating, and that as long as the president appears attentive to those concerns they can cover their political bases without

asking for sacrifices or risking the possible failure of a more controversial energy policy."

Lugar, a veteran pol, is no doubt correct about the pressures the next president will face. What we can only hope is that by the time he or she is chosen, the signals from an overheating energy economy will have reached a point where platitudes no longer suffice—where it is possible to embark on a "controversial energy policy," to ask voters to make sacrifices, and above all, to push America, the champion of globalization, out of a posture of self-absorption and into a stance that is genuinely and sustainably global—at which point the Saudi ambassador really would have something to worry about.

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EXPLORING THE ISSUE

Should the United States Eliminate Its Dependence on Foreign Oil?

Critical Thinking and Reflection

1. What distinguishes energy independence from energy security?
2. What impact would legislation that promotes independence from foreign oil have on domestic economic growth and development?
3. Will a strategy of energy independence or energy security better foster investment into the development and use of alternative energy sources?
4. Describe some public policies that could promote independence from foreign oil for the United States. Describe some public policies that could promote energy security for the United States. Discuss the commonalities and differences between the policies that would promote these two different strategies.

Is There Common Ground?

Most people agree that policies that would help reduce energy costs for Americans and leave the United States less vulnerable to other countries would be in the best interest of the United States. The difficult question remains whether a strategy of energy independence that would allow the United States to be completely free of the need to import oil from other states is realistic, prudent, or truly sustainable.

Both those in favor of and those against the pursuit of energy independence note the importance of investing in energy research and development. However, some favor investment in the extraction of more domestic oil, whereas others would like to see more investment in alternative energy sources. Over the past three decades, the dominant focus of research and development funding in the United States has been on the development of new extraction methods and the identification of new reserves. In fact, funding for research on alternative, renewable energy sources was three times greater in 1979 than it has been during this period. The need for greater attention to alternative energy source development may be another potential source of common ground for both proponents and critics of energy independence.

If market prices for oil keep rising, then this may make "policy choices for secure energy much easier . . . [by stimulating] production of non-OPEC conventional and nonconventional oil substitutes" (Griffin, 2009). Such policies could further both energy independence and energy security, as these two ideas are not diametrically opposed. Shifting the energy sector toward a nonoil-based infrastructure over the long term could allow for the gradual substitution of oil for other energy sources, once they are developed, and prove that they can also enable economic growth and improvements in standards of living. Whether the United States will be able to take a proactive approach to this transition, or whether it will merely react through disparate and inefficient responses to energy crises, remains to be seen.

Additional Resources

Cordesman, Anthony H. and Khalid R. Al-Rodhan. *The Global Oil Market: Risks and Uncertainties*. Washington, DC: Center for Strategic and International Studies Press, 2006.

Griffin, James M. *A Smart Energy Policy: An Economist's Rx for Balancing Cheap, Clean, and Secure Energy*. New Haven, CT: Yale University Press, 2009.

Hakes, Jay. *Declaration of Energy Independence: How Freedom from Foreign Oil Can Improve National Security, Our Economy, and the Environment*. Hoboken: John Wiley and Sons, Inc., 2008.

This author argues that energy independence is a prudent strategic objective for the United States, yet each presidential administration has impeded the goal through contrary energy policies. The book explains how energy independence can still save the United States from its impending energy crisis by outlining seven economic and political ways that America can produce and use energy more efficiently and break its dependence on foreign oil.

Jordan, Amos A., William J. Taylor, Jr., Michael J. Meese, and Suzanne C. Nielsen. *American National Security*, 6th ed. Baltimore, MD: Johns Hopkins University Press, 2009.

Simmons, Matthew R. *Twilight in the Desert: The Coming Saudi Oil Shock and the World Economy*. Hoboken: John Wiley & Sons, Inc., 2005.

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The Oil Crisis

This article describes the current energy crisis, indicating that, based upon geological and oil discovery trends, the supply of conventional oil will not keep up with the demand for oil within the next decade.

www.oilcrisis.com/_archive/ScientificAmerican199803/EndOfCheapOil.htm

The Financial Times

This article examines whether energy independence is more viable for the United States now than in past years. The author argues that the benefits of self-sufficiency include importing less oil, improving the United States' current account deficit, and mitigating OPEC's power.

www.ft.com/cms/s/65bfd07a-03b3-11e1-bbc5-00144feabdc0

The American Interest

This article examines the difficulties associated with decreasing supplies of relatively cheap, easily accessible, and viscous oil sources in the face of rapidly growing consumer demand. The author suggests that the increasing costs of extracting the remaining oil will push consumers to accept and adopt alternative energy technologies.

www.the-american-interest.com/article.cfm?piece=446

Reuters

This article examines oil price spikes and the physical availability of oil and concludes that energy independence is not a feasible strategy due to the global nature of the oil market.

www.reuters.com/article/2011/11/30/column-us-exports-energy-independence-idUSL5E7MU6OT20111130

USA Today Online

Tim Mullaney's "U.S. Energy Independence is no Longer a Pipe Dream," is available at this link.

www.usatoday.com/money/industries/energy/story/2012-05-15/1A-COV-ENERGY-INDEPENDENCE/54977254/1

Pickens Plan

T. Boone Pickens' piece, "The Plan," is available at this link.

www.pickensplan.com/theplan

U.S. Energy Information Administration

"Primary Energy Consumption by Source and Sector, 2010" is available at this link.

www.eia.gov/totalenergy/data/annual/pecss_diagram.cfm

ISSUE

Selected, Edited, and with Issue Framing Material by:
Thomas A. Easton, *Thomas College (Ret.)*

Would a Carbon Tax Help Slow Global Warming?

YES: James Rydge, from "Implementing Effective Carbon Pricing," *The New Climate Economy* (2015)

NO: Robert P. Murphy, Patrick J. Michaels, and Paul C. Knappenberger, from "The Case Against a Carbon Tax," Cato Institute (2015)

Learning Outcomes

After reading this issue, you will be able to:

- Explain what carbon pricing is.
- Explain how carbon pricing could help reduce emissions of greenhouse gases.
- Explain why international cooperation is essential to a working carbon pricing scheme.
- Explain what is meant by the "social cost of carbon."
- Discuss whether or not it is fair for Americans to pay for a "social cost of carbon" that affects other nations.

ISSUE SUMMARY

YES: James Rydge argues that the case for using carbon pricing (via a carbon tax or a cap-and-trade system) as an important component of efforts to bring carbon emissions and their effects on global climate change under control is strong, momentum is growing, and effects on competitiveness can be dealt with via international cooperation. Therefore, all developed and emerging economies, and others where possible, should commit to introducing or strengthening carbon pricing by 2020, and should phase out fossil fuel subsidies.

NO: Robert P. Murphy, Patrick J. Michaels, and Paul C. Knappenberger argue that the economics of climate change reveal that the case for a U.S. carbon tax is very weak, partly because reining in global warming cannot be justified in cost/benefit terms. Even a well-designed carbon tax would probably cause more harm than good.

The Environmental Protection Agency (EPA) was established in 1970 in response to concerns about air and water pollution. During the next two decades an unprecedented series of legislative acts and administrative rules were promulgated, placing numerous restrictions on industrial and commercial activities that might result in the pollution, degradation, or contamination of land, air, water, food, and the workplace.

Such forms of regulatory control have always been opposed by the affected industrial corporations and developers as well as by advocates of a free-market policy. More moderate critics of the government's regulatory program recognize that adequate environmental protection will not result from completely voluntary policies. They suggest that a new set of strategies is needed. Arguing that "top down, federal, command and control legislation" is not an appropriate or effective means of preventing environmental degradation, they propose a wide range of alternative tactics, many of which are designed to operate through the economic marketplace. The first significant congressional response to these proposals was the incorporation of tradable pollution emission rights into the 1990 Clean Air Act amendments as a means for reducing acid rain–causing sulfur dioxide emissions. More recently, the 1997 international negotiations on controlling global warming,

held in Kyoto, Japan, resulted in a protocol that includes emissions trading as one of the key elements in the plan to limit the atmospheric buildup of greenhouse gases.

Charles W. Schmidt, "The Market for Pollution," *Environmental Health Perspectives* (August 2001), argues that emissions trading schemes represent "the most significant developments" in the use of economic incentives to motivate corporations to reduce pollution. However, many environmentalists oppose the idea of allowing anyone to pay to pollute, either on moral grounds or because they doubt that these tactics will actually achieve the goal of controlling pollution. Diminishment of the acid rain problem is often cited as an example of how well emission rights trading can work, but in "Dispelling the Myths of the Acid Rain Story," *Environment* (July–August 1998), Don Munton argues that other control measures, such as switching to low-sulfur fuels, deserve much more of the credit for reducing sulfur dioxide emissions. Recent assessments of the acid rain program by the EPA and such organizations as the Environmental Defense Fund are more positive. So is the corporate world: In September 2001, *The Economist* ("Economic Man, Cleaner Planet") reported that economic incentives have proved very useful and "market forces are only just beginning to make inroads into green policymaking." In March 2002, *Pipeline and Gas Journal* reported that "Despite uncertainty surrounding U.S. and international environmental policies, companies in a wide range of industries—especially those in the energy field—are increasingly using emission reduction credits as a way to meet the challenges of cutting greenhouse gas emissions."

In "A Low-Cost Way to Control Climate Change," *Issues in Science and Technology* (Spring 1998), Byron Swift argues that the "cap-and-trade" feature of the U.S. Acid Rain Program has been so successful that a similar system for implementing the Kyoto Protocol's emissions trading mandate as a cost-effective means of controlling greenhouse gases should work. In March 2001, the U.S. Senate Committee on Agriculture, Nutrition, and Forestry held a "Hearing on Biomass and Environmental Trading Opportunities for Agriculture and Forestry," in which witnesses urged Congress to encourage trading for both its economic and its environmental benefits. Richard L. Sandor, chairman and chief executive officer of Environmental Financial Products LLC, said that "200 million tons of CO_2 could be sequestered through soils and forestry in the United States per year. At the most conservative prices of $20–$30 per ton, this could potentially generate $4–$6 billion in additional agricultural income."

A number of carbon trading schemes have been implemented, though with limited success. Europe's attempt to implement a cap-and-trade system to control carbon emissions did not work. According to Marianne Lavelle, "The Carbon Market Has a Dirty Little Secret," *U.S. News and World Report* (May 14, 2007), in Europe the value of tradable emissions allowances fell so low, partly because too many allowances were issued, that it became cheaper to burn more fossil fuel and emit more carbon than to burn and emit less. Clearly, future trading schemes would need to be designed to avoid this and related problems. Other approaches might also be needed, such as "carbon offsets," meaning that corporations, governments, and even individuals compensate for carbon dioxide emissions by investing in activities that remove carbon dioxide from the air or reduce emissions from a different source. See Anja Kollmuss, "Carbon Offsets 101," *World Watch* (July/August 2007). Unfortunately, present carbon-offset schemes contain loopholes that mean they may do little to reduce overall emissions; see Madhusree Mukerjee, "A Mechanism of Hot Air," *Scientific American* (June 2009).

On May 21, 2009, the House Energy and Commerce Committee approved H.R. 2454, the American Clean Energy and Security Act. The goal of the Act, said Committee Chair Henry A. Waxman (D-CA), was to "break our dependence on foreign oil, make our nation the world leader in clean energy jobs and technology, and cut global warming pollution. I am grateful to my colleagues who supported this legislation and to President Obama for his outstanding leadership on these critical issues." Among other things, the Act established Title VII of the Clean Air Act to provide a declining limit on global warming pollution (a "cap" as in "cap-and-trade") and to hold industries accountable for pollution reduction under the limit. The aim was to cut global warming pollution by 17 percent compared to 2005 levels in 2020, by 42 percent in 2030, and by 83 percent in 2050. In June 2009, the House of Representatives passed a version of the bill that also called for utilities to use more renewable energy sources. However, the Senate refused to pass any version of the bill at all.

According to the 2014 *Fifth Assessment Report* from the Intergovernmental Panel on Climate Change (ipcc.ch), the threat of global warming appears worse than ever, and it is clearer than ever that human-caused carbon emissions are responsible. And even in 2009, the Global Humanitarian Forum's "Human Impact Report: Climate Change—The Anatomy of a Silent Crisis" (May 29, 2009) said that global warming was already affecting over 300 million people and was already responsible for 300,000 deaths per year. Unfortunately, it is inevitable that the deadly impact of global warming must grow worse for many years before it can be stopped.

Yet the debate over the proper actions to take is by no means over. Some analysts argue that a carbon tax would be more effective; see Bettina B. F. Wittneben, "Exxon Is Right: Let Us Re-Examine Our Choice for a Cap-and-Trade System over a Carbon Tax," *Energy Policy* (June 2009). But that alternative has also failed to gain traction in Congress.

Cap-and-trade, carbon tax, and carbon offset schemes are all variations on the basic idea of putting a price on carbon (a "carbon price"), and all are variations on the idea that those who pollute should be obliged to make up in some way for the costs they impose on society and which are borne by institutions (taxpayers, insurance companies, etc.) outside the polluting corporations. Such costs are known as "negative externalities" (see http://economics.fundamentalfinance.com/negative-externality.php). Unfortunately, our society does not deal well with negative externalities, preferring instead to give polluters (such as the fossil fuel industry) subsidies (such as tax breaks) which encourage them to pollute more, instead of less. The International Monetary Fund recently made it clear that it considers climate change a threat to the world's economies and it is time to implement carbon pricing and end fossil fuel subsidies (Samantha Page, "Now Is the Time for a Carbon Tax, IMF Chief Says," *Climate Progress*, October 8, 2015; http://thinkprogress.org/climate/2015/10/08/3710467/imf-says-to-tax-carbon/). In the YES selection, James Rydge argues that the case for using carbon pricing (via a carbon tax or a cap-and-trade system) as an important component of efforts to bring carbon emissions and their effects on global climate change under control is strong, momentum is growing, and effects on competitiveness can be dealt with via international cooperation. Therefore, all developed and emerging economies, and others where possible, should commit to introducing or strengthening carbon pricing by 2020, and should phase out fossil fuel subsidies. In the NO selection, Robert P. Murphy, Patrick J. Michaels, and Paul C. Knappenberger argue that the economics of climate change reveal that the case for a U.S. carbon tax is very weak, partly because reining in global warming cannot be justified in cost/benefit terms. Even a well-designed carbon tax would probably cause more harm than good.

YES

James Rydge

Implementing Effective Carbon Pricing

Overview

Support for carbon pricing is growing around the world. Governments, businesses and investors are recognising that nationally-appropriate taxes and trading schemes, as part of a well-aligned package of policies for low-carbon change, can reduce greenhouse gas (GHG) emissions without harming the economy. Strong, predictable and rising carbon prices send an important signal to markets, helping to align expectations on the direction of change, thereby steering consumption choices and the type of investments made in infrastructure and innovation. They also raise fiscal revenues that can be put to productive uses. Around 40 national jurisdictions and over 20 cities, states and regions, have adopted or are planning explicit carbon prices, covering about 12% of global GHG emissions. The number of carbon pricing instruments implemented or scheduled has almost doubled from 20 to 38 since 2012. Over 1000 major companies and investors have endorsed carbon pricing, and around 450 now use an internal carbon price (US$40/t CO_2 or higher for some major oil companies) to guide investment decisions, up from 150 companies in 2014.

While this momentum is encouraging, current price levels and coverage of emissions are still very low. Carbon prices vary significantly, from less than US$1 to US$130 per tonne of CO_2e, with around 85% of emissions priced at less than US$10 per tonne. This is considerably lower than the price that economic models suggest is needed to meet the 2°C global warming goal adopted by the international community.

International cooperation on carbon pricing and subsidy reform, in particular between countries of the G20, and with the support of the World Bank, the Organisation for Economic Co-operation and Development (OECD) and the International Monetary Fund (IMF), can help mitigate concerns holding back faster progress. Cooperation can help to overcome concerns about competitiveness impacts from unilateral policy action, improve knowledge-sharing and transparency, provide opportunities to link emission trading schemes, and reduce the costs of action.

Introduction

It is now widely acknowledged that one of the most important steps that governments in advanced and emerging economies can take to build a more robust economy and a safer climate is to put an explicit price on carbon. A strong, predictable and rising explicit carbon price—applied through policies appropriate to the national context, including carbon taxes or cap-and-trade systems—can send important signals across the economy, helping to guide consumption choices and investments towards low-carbon activities and away from carbon-intensive ones. It can also be a better way to raise revenue for productive uses than many existing taxes, such as on employment. Phasing out fossil fuel subsidies—effectively, negative carbon prices—is also crucial, as they distort markets and encourage wasteful use, contributing to air pollution and increasing importing countries' vulnerability to volatile prices.

Around 40 national jurisdictions and over 20 cities, states and regions, have implemented or scheduled an explicit price on carbon, covering an estimated 7 Gt CO_2e, or about 12% of annual global greenhouse gas (GHG) emissions. This is triple the coverage of a decade ago. The number of carbon pricing instruments (implemented or scheduled) has almost doubled from 20 to 38 since 2012. Concerns persist that pricing carbon will hurt industrial competitiveness, so most explicit prices are still quite low, less than US$10 per tonne of CO_2, and there is often no mechanism or plan to increase them. Several countries have also provided exemptions or special treatment to their most polluting energy-intensive industries, thus limiting the effectiveness of the carbon price.

International cooperation can help to overcome this barrier. Trading partners can coordinate the introduction of carbon prices of roughly comparable levels, and thus overcome competitiveness concerns. By working together, countries can also benefit from knowledge-sharing on best practice, along with greater transparency and the opportunity to link trading schemes.

Rydge, James. "Implementing Effective Carbon Pricing", The New Climate Economy, 2015. Copyright ©2015 by The Global Commission on the Economy and Climate. Used with permission.

Conditions are now particularly favourable for both carbon pricing and reform of fossil fuel consumption subsidies, due to the fall in global oil prices over the last year, combined with lower gas and coal prices. G20 countries have already agreed to phase out inefficient fossil fuel subsidies, and several are now acting with support of international institutions such as the International Monetary Fund (IMF), the International Energy Agency (IEA), the Organisation for Economic Co-operation and Development (OECD) and The World Bank. The Asia-Pacific Economic Cooperation (APEC) economies have made a similar commitment.

There is a strong case for countries to build on these commitments and introduce meaningful explicit carbon prices across countries at the same time. This working paper begins by looking at the strong momentum for carbon pricing around the world, including growing support from the private sector. It then examines the benefits of carbon pricing, and explains what is needed for successful implementation, drawing on lessons from different countries. Finally, it discusses how to advance international cooperation on carbon pricing, with particular attention to members of the G20.

Growing Momentum for Carbon Pricing

The use of explicit carbon pricing is increasing. In 2014, China launched two pilot regional emissions trading schemes (ETSs), bringing the total to seven, and announced plans to transition to a national carbon pricing system from 2017. The scheme will be the world's largest, twice the size of the European Union Emissions Trading System (EU ETS), covering around 3–4 billion tonnes of CO_2—equivalent to the total annual emissions of the European Union (EU), or India, Brazil and Japan combined. In January 2015, South Korea launched its ETS, the second largest cap-and-trade system in the world, covering more than 500 business entities from 23 sectors. Permits have traded in the range of US$7–8 per tonne. The European Union approved important reforms in 2014 to strengthen and revitalise its carbon market, and it has provisionally agreed that implementation of these reforms will be brought forward from 2021 to 2019. California and Quebec linked their carbon trading schemes in 2014, enabling trade in allowances and many other benefits, and in April 2015, Ontario announced that it will launch an ETS linked to the California and Quebec schemes.

As part of wider fiscal reforms, Chile approved a carbon tax in September 2014, to start in 2018; the rate is US$5 per tonne of CO_2e and applies to the power sector and large industries, covering around 55% of emissions. South Africa plans to introduce a carbon tax in 2016. . . .

Support for carbon pricing is also building in the private sector. Many major businesses, including in high-emitting sectors such as oil and gas, are now endorsing carbon pricing—an important shift after many years of business opposition. They see it as a way to drive efficiency and profitable new business opportunities. More than 1,000 businesses and investors expressed support for carbon pricing at the UN Climate Summit in September 2014, including BP, British Airways, Cemex, Braskem, Royal Dutch Shell, Statkraft, Unilever, Statoil and DONG Energy. At the time of writing 437 businesses are reported to be already using an internal carbon price in assessing investments, up from 150 in 2014. Shell, for example, uses a price of US$40 per tonne of CO_2e, Statoil ASA US$50, and ExxonMobil US$80. In May 2015, at the Business & Climate Summit 2015 in Paris, 25 global business networks representing more than 6.5 million companies called for "robust and effective carbon pricing mechanisms as a key component to gear investment and orient consumer behaviour towards low-carbon solutions and achieve global net emissions reduction at the least economic costs."

These developments reflect an increasing understanding of how to design successful carbon pricing policies and unlock their benefits at the national and corporate level; countries and businesses are recognising the wide range of economic benefits that are possible. They are also learning how to manage many of the challenges that can arise around these reforms, which may make it easier for others in the future.

Conditions are now particularly favourable for both carbon pricing and fossil fuel consumption subsidy reform due to the fall in global oil prices over the last year, combined with lower gas and coal prices. While it is not yet clear whether these lower fossil fuel prices will last, in the short term they can help to offset any energy price increases resulting from these measures, making it easier for consumers and businesses to adjust, and reducing political resistance. It is notable that a number of countries, including Mexico, India and Indonesia, have seized the opportunity to advance reform of fossil fuel subsidies over the last year. Many of these reforms are expected to be permanent—i.e., they are unlikely to be reversed if energy prices rise. This stronger momentum is supported by the G20 commitment to rationalise or phase out fossil fuel subsidies from 2009, which was reaffirmed again most recently in 2014, as well as a similar commitment from APEC countries.

The Economic and Climate Case for Carbon Pricing

. . . Experience with carbon prices to date suggests that they have four key benefits: they are an efficient way to reduce GHG emissions; they are a useful way to raise revenue to support public priorities; they provide wider environmental and energy security benefits; and they provide a clear and credible price signal to guide business expectations. Below we address each of these in turn, and examine key factors for successful implementation.

Carbon Prices Are an Efficient Way to Reduce GHG Emissions

Carbon prices set through broad-based taxes or cap-and-trade systems are an economically efficient way to tackle the greenhouse gas market failure. Recent evidence from the electricity sector indicates that these have been the cheapest policies to reduce emissions. Carbon prices come in many forms, and even non-price-based regulatory measures to reduce GHG emissions impose an "implicit" price on the release of carbon and thus can be considered "implicit carbon taxes." Here we focus on explicit carbon prices.

Governments have learned much about the design of explicit carbon pricing policy instruments over recent years. Key lessons and examples are summarised in the recent World Bank report, *FASTER Principles for Successful Carbon Pricing*.

One of the key lessons, for example, is that cap-and-trade systems need to be responsive to market shocks to maintain robust prices. Europe's economic downturn after the financial crash in 2008 called for downward adjustments to the caps in the EU ETS, but policy design did not allow this, leading to substantial surpluses and a sharp drop in prices. The EU ETS has been through a difficult time, but is now on a path to reform based on lessons learned. The European Commission has agreed to "backload" some permits, i.e. set aside until a later date, to reduce those surpluses, and has proposed a "market stability reserve" to help keep prices higher and less volatile.

In addition to good design, the broader policy context is important. A range of policies are needed to tackle different market failures and barriers—including structural, political and behavioural barriers—that can limit the effectiveness of the economic incentives created by carbon pricing. For example, additional policy instruments are needed to tackle barriers that are commonly faced by industry, such as short investment payback periods and capital constraints, prescriptive standards, entrenched customer preferences and other factors.

Carbon prices and complementary policies must also be well aligned and integrated, both within the policy package itself and across the wider economy. The OECD, together with the IEA, the International Transport Forum (ITF) and the Nuclear Energy Agency (NEA), recently published a landmark study on aligning and integrating policies for the transition to a low-carbon economy. They conclude that much can be done in non-climate policy portfolios to facilitate the implementation of core climate policy instruments, such as carbon pricing, and improve their effectiveness. "Misalignments" that unintentionally hinder the climate policy signal exist in finance, taxation, innovation and trade, as well as in sector-specific regulatory frameworks in electricity, mobility and land use. In such cases, policy reform can often have broader benefits for society and the climate, such as reduced costs, improved effectiveness, clearer market signals, and a generally lower risk of policy failure.

Fossil fuel subsidies are one of many examples of misalignment. They are often justified on the grounds of helping the poor or increasing the competitiveness of business and industry. However, energy and fossil fuel subsidies are inefficient ways of achieving these objectives, and there are much more effective approaches. For example, it is estimated that on average only 7% of the benefits from fossil fuel subsidies reach the poorest 20% of the population. Governments apply consumption subsidies in many ways, such as by keeping local energy prices below international market prices, or through grants or vouchers to make energy more affordable. Subsidies and tax breaks are also used to support the production of fossil fuels. These are essentially negative carbon prices. Together, these subsidies to fossil fuels add up to about US$600 billion per year. This includes consumption subsidies in emerging and developing economies of around US$548 billion in 2013, and fossil fuel exploration, production and consumption support in OECD countries of around US$55–90 billion a year.

Phasing out subsidies to the production and consumption of fossil fuels, as part of wider fiscal and energy sector reform, has many benefits. It can reduce the burden on national budgets; for example, support to fossil fuel consumption in 40 developing countries represents around 5% of GDP and 25–30% of government revenues. Reducing this economic distortion allows for a more productive and efficient allocation of resources, which can lead to gains in real incomes and GDP. Angola's spending on fossil fuel subsidies in 2014, for example, was higher than its spending on health and education combined, and

represented 3.7% of GDP. In its 2015 budget, the Angolan government cut fossil fuel subsidies by 60%.

Reforms also lead to higher energy prices. This can provide additional revenues for utilities to invest in upgrading or expanding supply infrastructure, in particular renewable energy, which becomes more competitive as fossil fuel prices rise. Pricing reforms are considered important for expanding energy access in sub-Saharan Africa, for example. At the same time, they encourage investment in energy efficiency and conservation, and reduce CO_2 emissions and air pollution from fossil fuel combustion, among other benefits.

There is growing momentum to reform fossil fuel consumption subsidies, helped in part by lower oil prices (which reduce the impact on energy price rises) and motivated by growing fiscal pressures, including in oil-exporting nations where consumption subsidies are often high. In addition to the reasons outlined earlier, reforms have also been motivated by fuel smuggling from countries with subsidised fuels to those without. (It is estimated, for example, that around 10% of fuel consumption is smuggled from Angola to the Republic of Congo and the Democratic Republic of Congo.) But it remains true that subsidy reform is very challenging institutionally and politically. . . .

There has been mixed success on reform of fossil fuel production subsidies. Lower oil prices have led to some increased calls from industry to increase production subsidies, and some governments have acted on such requests, in part due to the royalties they receive from these industries. In the UK, for example, the government already provides generous tax breaks to the oil and gas industry, but agreed to increase support for North Sea oil producers in 2015. In Alberta, Canada, however, a newly elected government has pledged to review the Province's royalties on fossil fuel production.

Carbon Pricing Instruments Can Be Useful for Raising Revenue to Support Public Priorities

The emerging evidence shows that carbon pricing is an effective way to reduce emissions without harming the economy. Sweden introduced its carbon tax in 1991; its economy grew by nearly 60% in 1990–2013 while emissions fell by 23%. In the Canadian province of British Columbia, there was no evidence that the carbon tax adversely affected GDP growth over the five-year period following its introduction in 2008. It did, however, lead to a large and unexpected drop in oil product consumption (reflecting the fact that more substitution options were available in practice than were predicted prior to the introduction of the carbon tax) and GHG emissions fell by about 10% in 2008–2011, compared with a 1% reduction in the rest of Canada. The nine US states in the Regional Greenhouse Gas Initiative (RGGI) grew their economies by 9.2% in 2009–2013—better than the other 41 states' 8.8%—while reducing their combined emissions by 18% (vs. 4% in the other states). A recent study found that in 2012–2014 alone, RGGI had a net economic benefit of US$1.3 billion on the nine member states' economies.

Economies are always changing, and those that embrace change do better. Governments need to undertake regular reforms to ensure their economies can respond to opportunities to maintain and enhance their efficiency, productivity and competitiveness. Fiscal reform is central to this task. Fiscal reform involving broad-based carbon prices provides an opportunity to lower the burden of existing taxes on work effort and capital accumulation. This can provide incentives for increasing employment and investment, thus boosting growth. For example, British Columbia has used its carbon tax revenues, around 3% of the total budget, to lower income and corporate taxes.

Multiple other benefits of this type of fiscal reform are becoming more widely acknowledged. For example, reducing taxes on work and capital reduces the incentive for people and businesses to stay in the informal sector (fully or partially) as a way to evade taxes. Carbon prices are also a higher-quality tax base over the short to medium term, as they are usually collected from a relatively small number of firms (e.g. electricity producers, fuel suppliers). This could be particularly valuable in counties with large informal sectors and/or tax evasion problems, as ensuring compliance could be easier and less costly compared with other broader-based taxes.

Governments can use carbon tax revenues in a number of ways. The use of revenues should be guided by good principles of public finance, including efficiency, and consideration of distribution and incidence, i.e. where the burden of the tax falls. Some potential productive uses include: reducing existing distortionary taxes, as discussed above; reducing public sector debt/GDP ratios (e.g. the introduction of a carbon tax in Ireland in 2010 raised much-needed revenues and avoided even harsher fiscal tightening measures); spending on public priorities such as health and education; funding innovation (e.g. Quebec and California use revenues from their ETS auctions to fund low-carbon technology advancement); financing international climate action and other climate policies (e.g. the EU distributes EU ETS auction revenues

to EU Member States, which use them to fund innovation and climate- and energy-related activities, among other things); and public financing support for infrastructure investment, for example by capitalising green investment banks. The most productive uses will differ by country, based on their existing social and economic structures, including tax.

Governments often also use a share of the carbon tax revenues to compensate those who are disadvantaged by reform, including consumers facing higher energy prices. Although carbon pricing will increase the efficiency of resource use, with net economic benefits overall, some people and economic sectors may be adversely affected. Neglecting them, or failing to clearly communicate the policies that are put in place to help smooth the transition, has been a major factor in strong resistance to carbon pricing. In most cases, clear and well-communicated policies will be needed to alleviate any distributional impacts on affected groups, in particular on poorer households. . . . This needs to be well targeted and may be in the form of cash transfers or social security payments, reductions in marginal income tax rates, or financial help to invest in energy efficiency measures that can offset higher energy bills. International institutions such as the World Bank are helping countries to develop such complementary compensation policies. The more revenue is spent on compensation, of course, the less is available for other productive uses.

Wider Environmental and Economic Security Benefits from Carbon Prices

These include local environmental benefits from reduced local air pollution, reduced traffic congestion, and better-functioning ecosystems. The human health and avoided mortality benefits of reducing health pollution are particularly large. The World Health Organization (WHO) has estimated that, in 2012, outdoor air pollution—much of it linked to fossil fuel use—caused 3.7 million premature deaths. . . . [T]he value of premature deaths from PM2.5 air pollution averaged the equivalent of over 4% of GDP in the 15 largest CO_2 emitters in 2010. Measures that reduce greenhouse gases and air pollution together in these countries would yield health benefits valued at US$73 per tonne of CO_2 abated. Carbon pricing can also drive enhanced energy security in energy-importing nations by reducing their reliance on fossil fuels. Moreover, by driving investment in energy efficiency and renewable energy, a carbon price can reduce exposure to increasingly volatile fossil fuel prices and less risk of disruption to energy supplies.

Clear and Credible Price Signals to Guide Expectations

Clear and credible price signals across the economy can align expectations and help provide the private sector with the certainty needed to invest in the three key drivers of growth, resource efficiency, infrastructure and innovation. This can help to accelerate and scale up investments in more efficient products, new business models, new markets, new skills and jobs, and more productive ways of working and operating.

Where carbon prices have long-term credibility, and are aligned with complementary policies, they can provide the incentive to invest in low-carbon infrastructure. Even though such investments will often lead to significant returns over time, clear long-term policy signals can help to ensure upfront financing is available given that the low-carbon investments often have high upfront costs and different risk-return profiles from high-carbon investments. Weak, absent or unclear carbon price signals will slow investment and change and increase the economic and social costs of a low-carbon economic transition.

Experience shows that many existing carbon prices have failed to send a clear and strong signal, limiting their effectiveness. This was the case initially with the EU ETS, for example, which has been hampered by a surplus of permits and resulting low prices, a lack of credibility around the future of the policy, and unclear signals as key energy-intensive industries were given overly generous compensation. As of April 2015, allowances in the EU ETS were trading at around US$8 per tonne of CO_2e, and in California, at around US$13 per tonne.

Weak carbon prices, including fossil fuel subsidies, also fail to send clear low-carbon signals to investors. This is reflected in the continued high levels of investment in fossil fuel-based energy, around US$950 billion in 2013. Price floors, as used in the UK, California and in the seven Chinese pilot schemes, can ensure a minimum price level in emissions trading, providing greater certainty and more consistent policy signals. This ensures that industries covered by the carbon price, investors and technology providers can make decisions knowing what the minimum price in the system will be at any time in the future.

However, with or without price floors, current prices are likely to be too low to send clear and sufficient signals to investors, consumers and technology providers. As of April 2015, prices in China's emissions trading pilot schemes were in the range of US$4–8 per tonne. South Korea and Switzerland's ETS prices were around US$9 per tonne. South Africa's carbon tax is planned to start in early 2016 at about US$10 per tonne of CO_2, and

rise by 10% per year, but with substantial tax exemptions in some sectors. Ireland, Denmark and British Columbia have carbon taxes in the US$22–24 range. France, which in its 2014 budget adopted a carbon tax of €7 per tonne of CO_2, raised it to €14.50 for 2015. It will increase to €22 for 2016 and legislation approved in July 2015 will raise the tax to €56 in 2020 and to €100 in 2030. Sweden has a price of US$130 per tonne of CO_2e in some sectors. This has sent clear signals that have led to a strong economy and large emissions reductions at the same time.

Many estimates of the costs of projected climate change, including from modelling exercises, also suggest higher carbon prices would be appropriate. For example, analysis for the US government has recommended a "social cost of carbon" (an estimate of the economic damage associated with a one tonne increase in carbon dioxide emissions in a given year) of around US$36 per tonne of CO_2 (the average of US$11–56, with the low end based on a higher discount rate), rising to around US$50 (US$16–73) in 2030. Prices today are also at the lower end of the spectrum of internal carbon prices that businesses are already applying to guide their own internal investment decisions. In 2015 the Carbon Disclosure Project (CDP) found 437 worldwide were using internal carbon prices as a tool to drive investments in GHG emission reductions and mitigate risks from future climate policies. Nearly 600 other companies said they are considering carbon pricing in the next two years. The prices reported ranged from under US$1 to over US$150 per tonne of CO_2e. Several of the companies are in the oil and gas sector, such as Shell (US$40), ConocoPhillips (US$6–51) and ExxonMobil (US$80), but the list also includes companies in a wide range of other sectors, such as Google (US$14), Microsoft (US$4.4), Disney (US$10–20), and Nestlé (US$15.47). . . .

International Cooperation

A Better Way to Overcome Competitiveness Concerns

We have learned a great deal from experiences to date with carbon pricing at the national and regional levels, and there is growing evidence that carbon pricing is good for both the economy and the climate. But there are still major impediments to scaling up the use of carbon pricing across sectors and countries because of anxieties around competitiveness impacts. Greater international coordination on pricing carbon and reforming fossil fuel subsidies can help to minimise the real or perceived impacts on competitiveness of unilateral action.

Recent evidence from carbon pricing shows that these concerns around competitiveness have not materialised on a significant scale in practice. . . . [T]he direct competitiveness impacts of a carbon price are small for countries that moved early, and there is little evidence of "carbon leakage" (the movement of production and emissions to locations with less stringent climate policy). This is partly due to the lack of stringency of carbon prices to date. And the latest research suggests that even at higher carbon prices, the impacts on industrial competitiveness in Europe are likely to be low.

Nevertheless, there are often concerns about the potential competitiveness impacts and carbon leakage from high carbon prices for a small group of carbon-intensive and trade-exposed industries, such as cement, paper, metals and chemicals, which compete largely on cost. These risks are real where carbon price signals are strong and the stringency of climate policies differ significantly across jurisdictions. However, the actual impact from higher carbon prices on competitiveness and location decisions is complex and hard to ascertain, and must be examined in the context of the wider business environment. In practice, investment and production location decisions are determined by a range of factors, such as proximity to product markets, transport costs, construction costs of new facilities, labour costs, access to materials, business risk, other taxes, local institutions and local infrastructure, with climate policy generally a less significant issue. Other factors may also come into play, including the intensity of competition, opportunities for abatement in a sector, profitability, and price sensitivity of customers. Different policies have been used or proposed to tackle these concerns, including free allocation of allowances and border carbon adjustments (BCAs). Both of these approaches are problematic, however.

Many emissions trading systems have allocated permits for free to industry. Methods of free allocation (e.g. grandfathering, output-based allocation and fixed sector benchmarking) differ in terms of administrative complexity and effectiveness in preventing leakage, and need to be revised over time, but they all reduce the potential benefits of carbon pricing, since the revenues that could have been put to productive use are forgone. Today, this practice is increasingly confined to shielding trade-exposed and emissions-intensive industries from perceived adverse effects on their international competitiveness, as in the EU ETS. In the power sector, free permits are mostly limited to situations where producers cannot pass on carbon costs (as in China), but in Eastern Europe, for example, they still support large and politically influential coal-fired generators. Governments have also kept

effective tax rates on the carbon content of different types of energy use low, on average, with taxes on high-emitting types of energy, such as coal, low or non-existent in many countries.

Other forms of compensation can include lump-sum rebates; administrative exemptions; support for energy efficiency improvements; payments to reskill workers or restructure operations (to increase efficiency and competitiveness in the medium to long term); or funding for low-carbon research and development. Experience suggests that the level of compensation required to ensure an initial profit-neutral impact from carbon pricing is likely to be relatively small, perhaps around 15% of total carbon tax revenues, according to some analyses. Where compensation is provided, there are good grounds for making it temporary, with clear phase-out plans as the industry and firms adjust and the competitiveness concerns subside, and governments should avoid applying total exemptions from carbon prices.

Some have called for the introduction of BCAs, measures that would apply a tax on the carbon embedded in traded products and services. Some commentators have argued that they would "level the playing field" with countries with weak or no climate policies. BCAs have also been suggested as a "threat" to spur countries towards more comprehensive global climate action. . . . [H]owever, they are controversial, especially where they are seen as discriminating against developing countries, and significant technical and administrative challenges exist around their implementation.

Compensation, including free allowances, and BCAs are second-best instruments. A better approach is to coordinate policies internationally to overcome these competitiveness and leakage concerns, by reducing the differences in pricing and subsidy policies between trading partners. We now have the experience and momentum to move to the first-best option. Sharing knowledge and experience among countries on the factors that have enabled successful reforms, as well as the challenges, is the first step to international cooperation.

How to Foster Greater International Cooperation on Carbon Pricing

As noted earlier, carbon pricing is already spreading around the world. Several initiatives are helping to accelerate action. The World Bank is working with the We Mean Business Coalition of major corporate associations and other partners to increase knowledge on how to design and implement successful carbon pricing systems through the Carbon Pricing Leadership Coalition (CPLC). They are developing forward-looking carbon pricing pathways that look at how business and government can define the business and economic case for carbon pricing. As mentioned above, the World Bank Group and the OECD, with inputs from the IMF, have also developed a set of principles for successful carbon pricing, based on the lessons learned from carbon pricing experience in jurisdictions around the world. Their report contains many rich examples that complement the work in this paper. The aim of this work is to enlarge the number of countries and businesses adopting and supporting carbon pricing prior to the UN Climate Change Conference (COP21) in Paris and beyond.

The World Bank Partnership for Market Readiness (PMR) has also helped to accelerate action. The PMR provides support to countries to prepare and implement carbon pricing instruments, and other climate policies, with the aim of scaling up emissions reductions. It serves as a platform to share lessons between countries and organisations. The International Carbon Action Partnership (ICAP) also runs summer schools and training for officials of governments considering introducing carbon pricing.

These initiatives should not be taken to mean that a common carbon pricing policy instrument will be implemented across countries. The actual policies and prices adopted will vary widely, with each country or region in most cases choosing its own "bottom-up" policies. Instruments are chosen and designed, and prices set, to reflect each country's climate ambition, increasingly as expressed in its INDC, the existing economic structure and policy landscape, including other climate and energy policies; and a range of other political, social and economic factors, as alluded to above.

Nevertheless, analyses have shown that there are potential benefits from linking carbon pricing schemes across countries or sub-national regions, to minimise price differences. This can send a more consistent and credible global price signal that aligns expectations worldwide on the direction of change. Linking cap-and-trade schemes can also lower the cost of a given level of emission reductions—for example, by ensuring the lowest-cost emissions reductions are realised across the linked countries, reducing price volatility and increasing market liquidity. It also helps to reduce competitiveness concerns and potential for emissions "leakage" from having multiple unconnected carbon markets with different prices and levels of effort.

In practice, the benefits of linking are greatest when markets have a similar size, similar levels of ambition, and other common features, such as the types of price controls and allocation methods used. The extent of existing

tax and externality distortions is also relevant. Most of the roughly 20 cap-and-trade schemes in operation have established or proposed at least one international linkage with another cap-and-trade or credit system. California and Quebec linked their carbon pricing schemes in 2014, and Ontario will soon join them. Quebec faces the biggest impact from its linking with California. As Quebec has a far smaller market, just over one-sixth the size of California's, lower emissions intensity and fewer cheap abatement opportunities, the carbon price in Quebec will fall substantially and largely be determined by California. The Californian price will rise slightly from linking. These differentials mean that Quebec will purchase excess allowances from California resulting in a net flow of revenue to California. The EU ETS already links 31 countries, with potential to be extended to other neighbouring countries. RGGI links nine US states in a relatively compact area, whose economies and energy systems are fairly interconnected.

There are three key ways for countries to increase their cooperation on carbon pricing:

1. *Commit to carbon pricing:* The G20 has a unique opportunity to lead on carbon pricing. It made a commitment on the phase-out of inefficient fossil fuel subsidies in 2009 and reaffirmed this repeatedly, most recently in 2014. This is an important piece of signalling, and it has marshalled institutional support from the OECD, the World Bank, the IEA and the IMF, which are providing research and helping countries to implement reform.

   There is a clear opportunity now for the countries of the G20 to build on these initial efforts. Prior to the Paris Climate Change Conference, it would send a strong signal if G20 countries committed at the G20 Leaders Summit in Turkey this November to establishing clear, credible and rising explicit carbon prices across their economies, as part of a well-aligned and integrated multiple policy framework for low-carbon growth and development. This would help to progress the international climate agreement in Paris and support stronger domestic action. The exact approach for G20 countries to implement the commitment could be agreed in Beijing in 2016. A coalition of "countries of the willing" could also form to start early action and demonstrate leadership in the G20.

   Countries beyond the G20 could also commit to introducing carbon pricing policies, including the phasing out of fossil fuel subsidies, in a way that is consistent with this commitment, subject to their own institutional capacity and support from international organisations to implement such policies. A sensible first step in many countries is to mandate monitoring, reporting and verification (MRV) of emissions for businesses and industry.

   In addition, strategies to link between different carbon pricing schemes to maximise the benefits from linking could be explored, and the existing linkages could be strengthened.
2. *Commit to annual reporting on action and progress:* A coordinated group of international institutions, such as the OECD, the IEA and the IMF, could work together to promote transparency and create clear and aligned expectations among businesses and investors on the level and direction of subsidy phase-out and carbon pricing in the G20 and other countries. This could also be reflected, for example, in the World Bank's annual *State* and *Trends of Carbon Pricing* report, where plans are already underway to begin assessing the effectiveness of existing and planned carbon pricing systems, which will add an important qualitative element to the international debate and assessment of progress.
3. *Commit to knowledge-sharing that builds on existing peer review processes:* Achieving these commitments will require sharing knowledge of best practices across G20 countries and with other countries. Mutual learning and review, in particular with neighbouring countries, can help to build trust, and accelerate and scale up action. The G20 and APEC are undertaking voluntary peer review processes on fossil fuel subsidies, and this could be extended to carbon pricing. And international institutions are already providing support for fossil fuel subsidy reform and now also for carbon pricing; their role could be strengthened to better support country efforts to make progress.

Conclusion and Recommendation

The case for carbon pricing is strong, and there is growing momentum. The use of carbon pricing is increasing as awareness of its multiple benefits grows and countries understand how to manage the costs of change better, such as by ensuring a just transition for affected workers and alleviating impacts on low-income households. Learning from recent experiences of carbon pricing around the world can help countries and businesses implement carbon pricing successfully. Governments are also realising that carbon pricing is central to structural reforms for

managing economic change and the climate risk that they will face over the coming decades.

Cooperation across G20 or other willing governments is essential if the world is to accelerate action on carbon pricing. It can promote learning and reduce many of the perceived risks of carbon pricing, such as competitiveness concerns, and thereby reduce political resistance. Countries of the G20 are well placed to take the lead and 2015 provides a good opportunity to cooperate around the establishment or strengthening of carbon prices.

The global mitigation potential in 2030 from implementing this commitment is significant. Mitigation analysis conducted for this report, based on IEA modelling scenarios, examined the impact on global GHG emissions if carbon prices increased to an average of US$75 per tonne of CO_2e in developed countries and US$35 per tonne in developing countries. (Fossil fuel subsidy phase-out was excluded due to uncertainty around the estimates.) The potential global annual emissions savings from this level of carbon pricing in 2030 are estimated to be in the order of 2.8–5.6 Gt of CO_2e. In the light of this analysis, **the Global Commission on the Economy and Climate recommends that all developed and emerging economies, and others where possible, commit to introducing or strengthening carbon pricing by 2020, and should phase out fossil fuel subsidies.**

Governments should integrate these measures into broader fiscal reform strategies, prioritising the use of resulting revenues to offset impacts on low-income households and for other productive uses such as financing reductions in existing distortionary taxes. Coalitions of willing governments should work together to enhance efficiency and minimise impacts on competitiveness, building on existing peer-review processes to share knowledge, and reporting annually on progress. All major businesses should adopt internal carbon prices in their business strategies, and actively support carbon pricing policy.

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The Case Against a Carbon Tax

Executive Summary

A vigorous campaign aimed at American policymakers and the general public has tried to create the perception that a federal carbon tax (or similar type of "carbon price") is a crucial element in the urgently needed response to climate change. Within conservative and libertarian circles, a small but vocal group of academics, analysts, and political officials are claiming that a revenue-neutral carbon tax swap could even deliver a "double dividend"—meaning that the conventional economy would be spurred in addition to any climate benefits. The present study details several serious problems with these claims. The actual *economics* of climate change—as summarized in the peer-reviewed literature as well as the U.N. and Obama Administration reports—reveal that the case for a U.S. carbon tax is weaker than the public has been told.

In the policy debate over carbon taxes, a key concept is the "social cost of carbon," which is defined as the (present value of) future damages caused by emitting an additional ton of carbon dioxide. Estimates of the SCC are already being used to evaluate federal regulations, and will serve as the basis for any U.S. carbon tax. Yet the computer simulations used to generate SCC estimates are largely arbitrary, with plausible adjustments in parameters—such as the discount rate—causing the estimate to shift by at least an order of magnitude. Indeed, MIT economist Robert Pindyck considers the whole process so fraught with unwarranted precision that he has called such computer simulations "close to useless" for guiding policy.

Future economic damages from carbon dioxide emissions can only be estimated in conjunction with forecasts of climate change. But recent history shows those forecasts are in flux, with an increasing number of forecasts of less warming appearing in the scientific literature in the last four years. Additionally, we show some rather stark evidence that the family of models used by the U.N.'s Intergovernmental Panel on Climate Change (IPCC) are experiencing a profound failure that greatly reduces their forecast utility.

Ironically, the latest U.N. Intergovernmental Panel on Climate Change (IPCC) report indicated that a popular climate target cannot be justified in cost/benefit terms. Specifically, in the middle-of-the-road scenarios, the economic compliance costs of limiting global warming to 2 degrees Celsius would likely be higher than the climate change damages that such a cap would avoid. In other words, the U.N.'s own report shows that aggressive emission cutbacks—even if achieved through an "efficient" carbon tax—would probably cause more harm than good.

If the case for emission cutbacks is weaker than the public has been led to believe, the claim of a "double dividend" is on even shakier ground. There really is a "consensus" in this literature, and it is that carbon taxes cause more economic damage than generic taxes on labor or capital, so that in general even a revenue-neutral carbon tax swap will probably reduce conventional GDP growth. (The driver of this result is that carbon taxes fall on narrower segments of the economy, and thus to raise a given amount of revenue require a higher tax rate.) Furthermore, in the real world at least *some* of the new carbon tax receipts would probably be devoted to higher spending (on "green investments") and lump-sum transfers to poorer citizens to help offset the impact of higher energy prices. Thus in practice the economic drag of a new carbon tax could be far worse than the idealized revenue-neutral simulations depict.

When moving from academic theory to historical experience, we see that carbon taxes have not lived up to the promises of their supporters. In Australia, the carbon tax was quickly removed after the public recoiled against electricity price hikes and a faltering economy. Even in British Columbia—touted as the world's finest example of a carbon tax—the experience has been underwhelming. After an initial (but temporary) drop, the B.C. carbon tax has not yielded significant reductions in gasoline purchases, and it has arguably reduced the B.C. economy's performance relative to the rest of Canada.

Murphy, Robert P.; Michaels, Patrick J.; Knappenberger, Paul C. "The Case Against a Carbon Tax", Working Paper No. 33, September 2015.

Both in theory and practice, economic analysis shows that the case for a U.S. carbon tax is weaker than its most vocal supporters have led the public to believe. At the same time, there is mounting evidence in the *physical* science of climate change to suggest that human emissions of carbon dioxide do not cause as much warming as is assumed in the current suite of official models. Policymakers and the general public must not confuse the confidence of carbon tax proponents with the actual strength of their case.

Introduction

Over the years, Americans have been subject to a growing drumbeat of the (ostensibly) urgent need for aggressive government action on climate change. After two failed attempts at a U.S. federal cap-and-trade program, those wishing to curb emissions have switched their focus to a *carbon tax*.

Although environmental regulation and taxes are traditionally associated with progressive Democrats, in recent years several vocal intellectuals and political officials from the right have begun pitching a carbon tax to libertarians and conservatives. They argue that climate science respects no ideology and that a carbon tax is a "market solution" far preferable to the top-down regulations that liberal Democrats will otherwise implement. In particular, advocates of a carbon tax claim that if it is *revenue neutral* then a "tax swap" deal involving reductions in corporate and personal income tax rates might deliver stronger economic growth *and* reduce the harms from climate change, whatever they might be.

Although they often claim to be merely repeating the findings of "consensus science," advocates of aggressive government intervention stand on very shaky ground. Using standard results from the economics of climate change—as codified in the peer-reviewed literature and published reports from the U.N. and Obama Administration—we can show that the case for a carbon tax is weaker than the public has been led to believe. Furthermore, the real-world experiences of carbon taxes in Australia and British Columbia cast serious doubt on the promises of a "market-friendly" carbon tax in the United States.

The present study will summarize some of the key issues in the climate policy debate, showing that a U.S. carbon tax is a dubious proposal in both theory and practice.

The "Social Cost of Carbon"

The "social cost of carbon" (often abbreviated SCC) is a key concept in the economics of climate change and related policy discussions of a carbon tax. The SCC is defined as the present-discounted value of the net future external damages from an additional unit of carbon dioxide emissions. In terms of economic theory, the SCC measures the "negative externalities" from emitting CO_2 (and other greenhouse gases expressed in CO_2-equivalents), and helps quantify the "market failure" where consumers and firms do not fully take into account the true costs of their carbon-intensive activities. To a first approximation, the "optimal" carbon tax would reflect the SCC (along the emission trajectory that would obtain with the carbon tax regime), and in practice the Obama Administration has issued estimates of the SCC that are being used in the cost/benefit evaluation of federal regulations (such as minimum energy efficiency standards) that aim to reduce emissions relative to the baseline.

It is important to note that the SCC reflects the estimated damages of climate change on the *entire world*. This means that if the SCC (calculated in this fashion) is used in federal cost/benefit analyses, the analyst is contrasting benefits accruing mostly to non-Americans with costs borne mostly by Americans. Whether the reader thinks this is valid or not, it is clearly an important issue that has not been made clear in the U.S. debate on climate change policy. In any event, the Office of Management and Budget (OMB), in its Circular A-4, clearly states that federal regulatory analyses should focus on domestic impacts:

> Your analysis should focus on benefits and costs that accrue to citizens and residents of the United States. Where you choose to evaluate a regulation that is likely to have effects beyond the borders of the United States, these effects should be reported separately.

However, when the Obama Administration's Interagency Working Group calculated the SCC, it ignored this clear OMB guideline, and only reported a *global* value of the SCC. Thus, if a regulation (or carbon tax) is thought to reduce carbon dioxide emissions, then the estimated benefits (calculated with use of the SCC) will vastly overstate the benefits *to Americans*.

As an affluent nation, the U.S. economy is much less vulnerable to the vagaries of weather and climate. Using two different approaches, the Working Group in 2010 "determined that a range of values from 7 to 23 percent should be used to adjust the global SCC to calculate domestic effects. Reported domestic values should use this range." Therefore, following OMB's clear guideline on reporting the *domestic* impacts of proposed regulations, the SCC value would need to be reduced anywhere from 77 to 93 percent, in order to show the benefit to Americans from stipulated

reductions in carbon dioxide emissions. To repeat, these figures all derive from the Obama Administration's own Working Group report.

In addition to such procedural problems with the use of the SCC in federal policy, there are deeper, conceptual problems. The average layperson may have the belief that the "social cost of carbon" is an empirical fact of nature that scientists in white lab coats measure with their equipment. However, in reality the SCC is a malleable concept that is entirely driven by the analyst's (largely arbitrary) initial assumptions. The estimated SCC can be quite large, modest, or even *negative*—this latter meaning that greenhouse gas emissions should arguably be subsidized to benefit humanity—depending on defensible adjustments of the inputs to the analysis.

The most popular current approach used by U.S. policymakers to estimate the SCC involves the use of computer-based Integrated Assessment Models (IAMs), which are complex simulations of the entire global economy and climate system for hundreds of years. Officially, the IAMs are supposed to rely on the latest results in the *physical* science of climate change, as well as *economic* analyses of the impacts of climate change on human welfare, where these impacts are measured in monetary units but include a wide range of non-market categories (such as flooding and loss of ecosystem services). With particular assumptions about the path of emissions, the physical sensitivity of the climate system to atmospheric CO_2 concentrations, and the impact on humans from changing climate conditions, the IAMs estimate the flow of *incremental* damages occurring centuries into the future as a result of an additional unit of CO_2 emissions in some particular year. Then this flow of additional dollar damages (over the centuries) can be turned into an equivalent present value expressed in the dollars at the date of the emission, using a discount rate chosen by the analyst, where this rate is typically *not* derived from observations of market rates of interest but is instead picked (quite openly) according to the analyst's ethical views on how future generations should be treated.

In May 2013, the Interagency Working Group produced an updated SCC value by incorporating revisions to the underlying three Integrated Assessment Models (IAMs) used by the IWG in its initial 2010 SCC determination. But, at that time, the IWG did *not* update the equilibrium climate sensitivity (ECS) employed in the IAMs. The ECS is a critical concept in the physical science of climate change. Loosely speaking, it refers to the long-run (after taking into account certain feedbacks) warming in response to a doubling of carbon dioxide concentrations. Thus, it is incredibly significant that the published estimates of the ECS were trending downward, and yet the Obama Administration Working Group did not adjust this key input into the Integrated Assessment computer models. Specifically, they made no downward adjustment in this key parameter in their May 2013 update despite there having been, since January 1, 2011, at least 15 new studies and 21 experiments (involving more than 45 researchers) examining the ECS, each lowering the best estimate and tightening the error distribution about that estimate. . . .

The abundance of literature supporting a lower climate sensitivity was at least partially reflected in the latest (2013) assessment of the Intergovernmental Panel on Climate Change (IPCC):

> Equilibrium climate sensitivity is *likely* in the range 1.5°C to 4.5°C (*high confidence*), *extremely unlikely* less than 1°C (*high confidence*), and *very unlikely* greater than 6°C (*medium confidence*). The lower temperature limit of the assessed *likely* range is thus less than the 2°C in the AR4 [Fourth Assessment Report] . . .

Clearly, the IWG's assessment of the low end of the probability density function that best describes the current level of scientific understanding of the climate sensitivity is indefensible.

The 2013 study of Otto et al., which was available at the time of the IWG's 2013 revision, is particularly noteworthy in that 15 of the paper's 17 authors were also lead authors of the 2013 IPCC report. Otto has a mean sensitivity of 2.0°C and a 5–95% confidence interval of 1.1 to 3.9°C. If the IPCC truly defined the consensus, that consensus has now changed. Instead of a 95th percentile value of 7.14°C, as used by the IWG, a survey of the recent scientific literature suggests a value of 3.5°C—more than 50% lower. This is very significant and important difference because the high end of the ECS distribution has a large impact on the SCC determination—a fact frequently commented on by the IWG.

Yet to repeat, the problem with the SCC as a tool in policy analysis goes beyond quibbles over the proper parameter values. At least the equilibrium climate sensitivity (ECS) is an *objectively defined* (in principle) feature of nature. In contrast, there are other parameters needed to calculate the SCC that by their very essence are subjective, such as the analyst's view on the proper weight to be given to the welfare of future generations. Needless to say, this approach to "measuring" the SCC 10 is hardly the way physicists estimate the mass of the moon or the charge on an electron. To quote MIT economist Robert

Pindyck (who *favors* a U.S. carbon tax) in his scathing *Journal of Economic Literature* article:

> And here we see a major problem with IAM-based climate policy analysis: The modeler has a great deal of freedom in choosing functional forms, parameter values, and other inputs, and different choices can give wildly different estimates of the SCC and the optimal amount of abatement. You might think that some input choices are more reasonable or defensible than others, but no, "reasonable" is very much in the eye of the modeler. **Thus these models can be used to obtain almost any result one desires.** [bold added.]

To see just how significant some of the apparently innocuous assumptions can be, consider the latest estimates of the SCC put out by the Obama Administration's Working Group. For an additional ton of emissions in the year 2015, using a 3% discount rate the SCC is $36. However, if we use a 2.5% discount rate, the SCC rises to $56/ton, while a 5% discount rate yields a SCC of only $11/ton. Note that this huge swing in the estimated "social cost" of carbon relies on the same underlying models of climate change and economic growth; the only change is in adjustments of the discount rate which are quite plausible. Indeed, the Administration's Working Group came under harsh criticism because it ignored explicit OMB guidance to include a *7 percent* discount rate in all federal cost/benefit analyses, presumably because the SCC at such a discount rate would be close to $0/ton or even negative.

The reason the Obama Administration estimates of the SCC are so heavily dependent on the discount rate is that the three underlying computer models all show relatively modest damages from climate change in the early decades. Indeed, one model (Richard Tol's FUND model) actually exhibits *net benefits* from global warming through about 3°C of warming relative to preindustrial temperatures. The higher the discount rate, the more weight is placed on earlier time periods (when global warming is not as destructive or is even beneficial) and the less important are the large damages that will not occur in the computer simulations until future 11 centuries. Economists do not agree on the appropriate discount rate to use in such settings, because the usual arguments in favor of market-based measures (which would yield a very low SCC) are not as compelling when we cannot bind future policymakers. Such are the difficulties in making public policy on the basis of threats that will not fully manifest themselves for another two generations.

If the economic models were updated to more accurately reflect the latest developments from the physical and biological sciences, the estimated "social cost of carbon" would likewise decline between one-third and two thirds, because lower temperature increases would translate into reduced climate-change damages. This is a sizeable and significant reduction.

Then there are problems with the climate models themselves. There is clearly a large and growing discrepancy between their predictions and what is being observed.

. . . John Christy of University of Alabama-Huntsville, dramatically shows the climate modelling problem in a nutshell. . . . [M]odel-predicted and observed temperatures, not at the surface, but in the lower troposphere, roughly from 5,000 to 30,000 feet, are less compromised by earth's complicated surface and man's role in altering it. More important, though, is that it is the vertical profile of temperature that determines atmospheric stability. When the "lapse rate," or the difference between the lowest layers and higher levels is large, the atmosphere is unstable. Instability is the principal source for global precipitation. While models can be (and are) "tuned" to mimic surface temperatures, the same can't be done as easily in the vertical.

. . . [T]he air above the surface is warming far more slowly than had been predicted, so that the difference between the surface and the upper air has changed very little. This means that observed global precipitation should be the same as it was. The forecast warming of the upper layers . . . would reduce the surface-to-upper air temperature difference, which would tend to reduce precipitation.

That means that the models themselves are making systematic errors in their precipitation projections. This has a dramatic effect on the resultant climate. When the surface is wet, which is what occurs after it rains, the sun's energy is directed towards the evaporation of that moisture rather than the direct heating of the surface. In other words, much of what we call "sensible weather" (the kind of weather you can sense) is determined by the vertical distribution of temperature. If the popular climate models get that wrong (which is what's happening) then all the subsidiary weather caused by it is also incorrectly specified.

Therefore there are problems and arbitrariness not just with the economic assumptions, but with the physical models that are used as input to the SCC calculations. The situation is even worse than described above by Pindyck.

So, even though the modelled sensitivities are dropping, there are still indications that the models themselves are too hot. None of the current batch of "official" SCC calculations accounts for this.

Besides the arbitrariness and/or dubious choices for the major input parameters, another problem with use of

the SCC as a guide to setting carbon taxes is the problem of *leakage*. Strictly speaking, it would make sense (even in textbook theory) to calibrate only a *worldwide and uniformly enforced* carbon tax to the SCC. If a carbon tax is applied only to certain jurisdictions, then emission cutbacks in the affected region are partially offset by increased emissions (relative to the baseline) in the non-regulated regions. Depending on the specifics, leakage can greatly increase the economic costs of achieving a desired climate goal, and thus the "optimal" carbon tax is lower if applied unilaterally in limited jurisdictions.

To get a sense of the magnitude of the problems of leakage, consider the results from William Nordhaus, a pioneer in the economics of climate change, and creator of the DICE model (one of the three used by the Obama Administration). After studying his 2007 model runs, Nordhaus reported that relative to the case of the entire globe enforcing the carbon tax, to achieve a given environmental objective (such as a temperature ceiling or atmospheric concentration) with only 50 percent of planetary emissions covered would involve an economic abatement cost penalty of *250 percent*. Even if the top 15 countries (by emissions) participated in the carbon tax program, covering three-quarters of the globe's emissions, Nordhaus still estimated that compliance costs for a given objective would be 70 percent higher than for the full-coverage baseline case.

To see the tremendous problem of limited participation from a different perspective, one can use the same model that EPA uses to calculate the effect of various policy proposals. The Model for the Assessment of Greenhouse-Gas Induced Climate Change (MAGICC) is available and easy-to-use on the Cato Institute website. MAGICC shows that even if the U.S. linearly reduced its emissions to *zero* by the year 2050, the average global temperature in the year 2100 would be 0.1°C—that's one-tenth of a degree—lower than would otherwise be the case. Note that this calculation does not even take into account "leakage," the fact that complete cessation of U.S. emissions would induce other nations to increase their economic activities and hence emissions. Our point in using these results from the MAGICC modeling is not to christen them as confident projections, but rather to show that *even on their own terms, using an EPA-endorsed model*, American policymakers have much less control over global climate change than they often imply.

U.N. Reports Can't Justify Popular Climate Goal

Although the goal's selection was never formally explained, advocates of government intervention to mitigate climate change have broadly settled on a *minimum* goal of limiting global warming (relative to preindustrial times) to 2°C, with many pushing for much more stringent objectives (such as limiting atmospheric greenhouse gas concentrations to 350 ppm of CO_2). Given the confidence with which carbon tax advocates refer to the "consensus" among scientists on the key issues in the climate change debate, the innocent American public would surely conclude that the periodic reports from the United Nations Intergovernmental Panel on Climate Change (IPCC) would *easily* justify implementation of government policies to hit the 2°C target.

Ironically, this is not the case. According to 2013 IPCC report [often referred to as "AR5" for "Fifth Assessment Report"], to "likely" limit global warming to 2°C would require stabilizing atmospheric concentrations between 430–480 ppm by the year 2100. The same AR5 report shows that achieving this climate goal would entail reductions in consumption in the year 2100 of 4.8 percent (which is the central estimate, and relative to the baseline). These are the *costs* of achieving the popular 2°C goal, according to the latest U.N. report.

In contrast, to compute the *benefits* of the 2°C goal we would need to know the *reduction* in climate change damages that would result under business-as-usual versus the mitigation scenario (with the temperature ceiling). Even under the most pessimistic emission scenario with no government controls (RCP8.5), by 2100 the AR5's central estimate of global warming is about 4.5°C, and a more realistic business-as-usual scenario (between RPC6 and RPC8.5) would involve warming by 2100 of less than 4°C. Therefore the *gross* benefits of the stipulated mitigation policy are the climate change damages from 4°C warming minus the climate change damages from 2°C warming.

Unfortunately, the AR5 report does not allow us to compute such figures, because just about all of the comprehensive analyses of the impacts of global warming consider ranges of 2.5°C–3°C. The AR5 *does* contain a table summarizing some of the estimates in the literature, out of which the most promising (for our task) are two results from Roson and van der Mensbrugghe's 2012 study. They estimated that 2.3°C warming would reduce GDP by 1.8 percent, while 4.9°C warming would reduce GDP by 4.6 percent. (Note that this particular estimate was the *only* one in the AR5 table that estimated the impact of warming higher than 3.2°C.)

Therefore, using ballpark figures, one could conclude from the AR5 summary of impacts that limiting climate change to 2°C rather than an unrestricted 4°C of warming, would mean that the Earth in the year 2100 would be spared about (4.6 − 1.8) = 2.8 percent of GDP loss in climate change damages. In contrast, the same IPCC AR5

report told us that the *economic compliance* costs of the mitigation goal would be 4.8 percent of consumption in the year 2100.

As this demonstration has shown, even if we take the IPCC's numbers at face value, and even assuming away the practical problems that would prevent mitigation policies from reaching the theoretical ideal, the popular climate goal of limiting global warming to 2°C would most likely entail greater economic damages than it would deliver in benefits (in the form of reduced climate change damages). The pursuit of more aggressive goals, and/or the use of imperfectly designed policy tools to achieve them, would, of course, only make the mismatch between costs and benefits even worse.

"Fat Tails" and Carbon Tax as Insurance?

As a postscript to these observations, we note that the leaders in the pro-carbon tax camp are abandoning traditional cost/benefit analysis as (allegedly) inappropriate in the context of climate change. For example, Harvard economist Martin Weitzman has warned that climate scenarios involve "fat tails" that (mathematically) make the conventionally-calculated social cost of carbon tend to infinity. Weitzman and others have moved away from treating a carbon tax as a policy response to a given (and known) negative externality, and instead liken it to a form of insurance pertaining to a catastrophe that *might* happen but with unknown likelihood. But the utility of such "insurance" is being compromised, given the strong emerging evidence very large warming is unlikely.

This approach, which is growing in popularity among the advocates of aggressive government intervention, has several problems. In the first place, the whole *purpose* of the periodic IPCC reports was to produce a compilation of the "consensus" research in order to guide policymakers. But when the models and methods contained in the IPCC reports do not yield aggressive enough action, critics such as Weitzman point out their (admitted) shortcomings and propose that policymakers take actions based on what we *don't* know. Yet as economist David R. Henderson points out, broad-based uncertainty cuts *both* ways in the climate change policy debate. For example, it is *possible* that the Earth is headed into a period of prolonged cooling, in which case offsetting anthropogenic warming would be beneficial—meaning that a carbon tax would be undesirable.

Another problem with Weitzman's approach—as Nordhaus, among other critics, has pointed out—is that it could be used to justify aggressive actions against *several* catastrophic risks, including asteroids, rogue artificial intelligence developments, and bio-weapons. After all, we can't *rule out* humanity's destruction from a genetically engineered virus in the year 2100, and what's worse we are not even sure how to construct the probability distribution on such events. Does that mean we should be willing to forfeit 5 percent of global consumption to merely reduce the likelihood of this catastrophe?

This question leads into the final problem with the insurance analogy: With actual insurance, the risks are well-known and quantifiable, and competition among insurers provides rates that are reasonable for the damages involved. Furthermore, for all practical purposes buying the insurance policy *eliminates* the (financial) risk. Yet to be analogous to the type of "insurance" that Weitzman et al. are advocating, a homeowner would be told that there was a roving gang of arsonists who might, decades from now, set his home on fire, that a fire policy would cost 5 percent of income every year until then, and that even if the house were struck by the arsonists, the company would indemnify the owner for only *some* of the damages. Who would buy such an "insurance" policy?

Carbon Tax Reform "Win-Wins"? The Elusive "Double Dividend"

Some proponents of a carbon tax have tried to decouple it entirely from the climate change debate. They argue that if the receipts from a carbon tax were devoted to reductions in taxes on labor or capital, then the economic cost of the carbon tax 18 would be reduced and might even be *negative*. In other words, they claim that by "taxing bads, not goods," the U.S. might experience a "double dividend" in which we tackle climate change *and* boost conventional economic growth.

Such claims of a double dividend are emphasized in appeals to libertarians and conservatives to embrace a carbon "tax swap" deal. For example, in a 2008 *NYT* oped calling for a revenue-neutral carbon tax swap, Arthur Laffer and Bob Inglis wrote, "Conservatives do not have to agree that humans are causing climate change to recognize a sensible energy solution." For another example, in his 2015 study titled, "The Conservative Case for a Carbon Tax," Niskanen Center president Jerry Taylor writes, "Even if conservative narratives about climate change science and public policy are to some extent correct, conservatives should say 'yes' to a revenue-neutral carbon tax."

The idea of revenue-neutral "pro-growth" carbon tax reform for the U.S. is arguably a red herring, as it is

very unlikely that any national politically feasible deal will respect revenue neutrality. On lower jurisdictions, note that Governor Jerry Brown wanted to use California's cap-and-trade revenue for high-speed rail, while the website for the Regional Greenhouse Gas Initiative (RGGI)—which is the cap-and-trade program for power plants in participating Northeast and Mid-Atlantic states—proudly explains how its revenues have been spent on renewables, energy efficiency projects, and other "green" investments. And far from insisting on revenue neutrality, Washington State Governor Jay Inslee wants to install a new state level cap-and-trade levy on carbon emissions to fund his $12.2 billion transportation plan.

Ironically enough, even Taylor *in his very study appealing to conservatives* touts a *non*-revenue-neutral carbon tax (which would impose a net tax hike of at least $695 billion in its first 20 years). It is possible that this was a mere oversight (i.e. that in his study Taylor genuinely believed he was pushing a revenue neutral plan but was simply ignorant of its details), but all doubts were removed a month later in a Niskanen Center post in which Taylor wrote: "But what if a tax-for-regulation swap were to come up in an attempt to address budget deficits and the looming fiscal imbalance? . . . But even were those fears realized, conservatives should take heart: using carbon tax revenues to reduce the deficit makes good economic sense."

With progressives enumerating the various "green" investments that could be funded by a carbon tax, and with even one of the leaders in the conservative pro-carbon tax camp laying the intellectual foundation for a net tax hike, it should be clear that a revenue-neutral deal at the federal level is very unlikely. . . .

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EXPLORING THE ISSUE

Would a Carbon Tax Help Slow Global Warming?

Critical Thinking and Reflection

1. Murphy et al. define the "social cost of carbon" in strictly financial terms. Are there nonfinancial costs of carbon emissions? What are some?
2. Murphy et al. object that the future effects of global warming have been overestimated, in part because the atmosphere has warmed less than expected in recent years. Look up "global warming hiatus" (start here: http://news.stanford.edu/news/2015/september/global-warming-hiatus-091715.html) and discuss whether their objection has merit.
3. In what ways do fossil fuel subsidies encourage continued emissions of greenhouse gases?

Is There Common Ground?

Both sides of this issue agree on at least one of the obstacles that stand in the way of a global carbon pricing effort. This is "leakage," which occurs when one country imposes carbon pricing on businesses that then move carbon-intensive operations such as manufacturing to other countries where they need not pay a carbon price. They differ on how straightforward it may be to overcome this problem. Searching on "carbon leakage" will find a great deal of information on the topic.

1. Which industries are likely to be affected by leakage? (See, e.g., http://www.carbontrust.com/media/84908/ctc767-tackling-carbon-leakage.pdf.)
2. Describe some of the methods that have been proposed for dealing with leakage.
3. Rydge suggests that international cooperation would be able to prevent or minimize leakage. What form would that international cooperation be likely to take?

Additional Resources

A. Denny Hillerman et al., *Pricing Carbon: The European Union Emissions Trading Scheme* (Cambridge University Press, 2010).

Larry Kreiser, Mikael Skou Andersen, Birgitte Egelund Olsen, Stefan Speck, Janet E. Milne, and Hope Ashiabor (eds.), *Carbon Pricing: Design, Experiences and Issues* (Elgar, 2015).

Karsten Neuhoff, *Climate Policy after Copenhagen: The Role of Carbon Pricing* (Cambridge University Press, 2011).

Internet References . . .

Carbon-Price.com

http://carbon-price.com/experts/

Global Subsidies Initiative

https://www.iisd.org/GSI/fossil-fuel-subsidies

The Carbon Trust

http://www.carbontrust.com/home/

The World Bank on Pricing Carbon

http://www.worldbank.org/en/programs/pricing-carbon

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ISSUE

Is It Necessary to Reduce Carbon Emissions to Fight Global Warming?

YES: D. J. Wuebbles, et al., from *Climate Science Special Report: Fourth National Climate Assessment*, Volume I, U.S. Global Change Research Program (2017)

NO: Kevin D. Dayaratna, Nicolas D. Loris, and David W. Kreutzer, from "Consequences of Paris Protocol: Devastating Economic Costs, Essentially Zero Environmental Benefits," Heritage Foundation Backgrounder (2016)

Learning Outcomes

After reading this issue, you will be able to:

- Describe the evidence that the global climate is warming.
- Describe the possible impacts of reducing carbon emissions on the U.S. economy.
- Describe the possible impacts of not reducing carbon emissions on the U.S. economy.
- Describe how climate change puts ecosystems at risk.

ISSUE SUMMARY

YES: D. J. Wuebbles, D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, and T. K. Maycock argue that, particularly given the tendency of climate models to underestimate the effects of carbon emissions (from large-scale combustion of fossil fuels and from deforestation), avoiding dangerous warming of the climate will require reducing net global CO_2 emissions.

NO: Kevin D. Dayaratna, Nicolas D. Loris, and David W. Kreutzer argue that trying to meet the requirements of the 2015 Paris Agreement by restricting the use of fossil fuels would harm several sectors of the U.S. economy with little if any benefit to the environment. By 2035, Gross Domestic Product (GDP) would lose $2.5 trillion, consumer electric bills would go up by 13 percent, and family income would lose $20,000.

The idea that the heat-trapping ability of infrared-absorbing gases in the atmosphere is similar to that of the glass panes in a greenhouse (hence the "greenhouse effect") was first proposed by the French mathematical physicist Jean-Baptiste-Joseph Fourier in 1827. In 1896, the Swedish chemist Svante Arrhenius, who later won the 1903 Nobel Prize in chemistry, predicted that if atmospheric carbon dioxide (CO_2) levels doubled due to the burning of fossil fuels, the resulting increase in the average temperature at the Earth's surface would amount to four to six degrees Celsius (seven to ten degrees Fahrenheit).

The Arrhenius prediction about global warming was all but forgotten for more than half a century until direct observations and historical data demonstrated that by 1960, atmospheric CO_2 levels had risen to 315 ppm from the preindustrial level of 280 ppm. Careful measurements since then have shown that the CO_2 level is now above 400 ppm, and rising (http://www.esrl.noaa.gov/gmd/ccgg/trends/). The Arrhenius prediction that the average temperature on Earth will rise more than four degrees Celsius may well come true before the end of the twenty-first century if present fossil fuel use and forest destruction trends continue. Most atmospheric scientists agree that such a warming will be accompanied by changes in the world's weather patterns and a significant increase in sea levels. The data on which these conclusions are based, as well as the conclusions themselves, have been vigorously debated for years.

In 1988, due to concern about the potentially serious disruptive effects that would result from significant, short-term changes in world climate, the United Nations Environment Programme joined with the World Meteorological Organization to establish the Intergovernmental Panel on Climate Change (IPCC) to assess the available scientific, technical, and socioeconomic information regarding greenhouse gas-induced climate change. Thousands of meteorologists and other atmospheric and climate scientists have participated in periodic reviews of the data. The Fifth Assessment Report of the IPCC appeared in 2013–2014. It concluded that it is very clear that global climate change is real, it is caused by human activities, and its impacts on ecosystems and human well-being (especially in developing nations) will be serious. It also outlined the steps that must be taken to prevent, ease, or cope with these impacts. Other reports (see Nicholas Stern, *Stern Review: The Economics of Climate Change*, Executive Summary, October 30, 2006 [http://webarchive.nationalarchives.gov.uk/20080910140413/http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm]) make it clear that although taking steps now to limit future impacts on global warming would be very expensive, "the benefits of strong, early action considerably outweigh the costs . . . Ignoring climate change will eventually damage economic growth. . . . Tackling climate change is the pro-growth strategy for the longer term, and it can be done in a way that does not cap the aspirations for growth of rich or poor countries. The earlier effective action is taken, the less costly it will be." More recently, James Hansen and colleagues report that because release of the greenhouse gases that cause global warming is increasing, we must now reduce emissions below zero, meaning that we must not only stop adding carbon dioxide to the atmosphere but also remove it from the atmosphere. "Proposed methods of extraction such as bioenergy with carbon capture and storage (BECCS) or air capture of CO_2" will cost at least "$89–535 trillion this century and also have large risks and uncertain feasibility. Continued high fossil fuel emissions unarguably sentences young people to either a massive, implausible cleanup or growing deleterious climate impacts or both" (J. Hansen, et al., "Young People's Burden: Requirement of Negative CO_2 Emissions," *Earth Systems Dynamics*, vol. 8, pp. 577–616, 2017).

Exactly what will global warming do to the world and its people? Richard B. Primack, *Walden Warming* (University of Chicago Press, 2014), has compared wildflower blooming times, as recorded in Henry David Thoreau's mid-1800s notebooks and found that warming has already shifted those times as much as six weeks earlier in the year. This does not sound very catastrophic, but our future is much more than a matter of wildflower blooming times. Projections have grown steadily worse; see Eli Kintisch, "Projections of Climate Change Go from Bad to Worse, Scientists Report," *Science* (March 20, 2009). Effects include rising sea level, more extreme weather events, reduced global harvests, reduced nutrient levels of crops (Mary Macvean, "Rising Carbon Dioxide Levels Affect Nutrients in Crops, Study Says," *Los Angeles Times*, May 7, 2014; http://www.latimes.com/science/sciencenow/la-sci-sn-carbon-dioxide-crops-20140507-story.html), and threats to the economies and security of nations (Michael T. Klare, "Global Warming Battlefields: How Climate Change Threatens Security," *Current History*, November 2007; and Scott G. Bergerson, "Arctic Meltdown: The Economic and Security Implications of Global Warming," *Foreign Affairs*, March/April 2008). As rainfall patterns change and the seas rise, millions of people will flee their homelands; see Alex de Sherbinin, Koko Warner, and Charles Erhart, "Casualties of Climate Change," *Scientific American* (January 2011). The potential for conflict is also emphasized in the IPCC's Fifth Assessment Report.

In June 2015, Pope Francis repeated this point more strongly; you can find his encyclical, "Laudato Si," at http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html. For a summary, see Emma Green, "The Pope's Moral Case for Taking on Climate Change," *The Atlantic* (June 18, 2015). Christopher J. Hale lists "The 5 Most Important Points of Pope Francis's Climate Change Encyclical," *Time.com* (July 2015) (http://time.com/3925520/pope-francis-climate-change-encyclical/), as:

1. Climate change is real, and it's getting worse.
2. Human beings are a major contributor to climate change.
3. Climate change disproportionately affects the poor.
4. We can and must make things better.
5. Individuals can help, but politicians must lead the charge.

Conservative politicians and anti–global warming forces have been vigorous in their reactions against this message. See Antonia Blumberg, "Fox News Pundit Calls Pope Francis 'The Most Dangerous Person on the Planet' for Suggesting Climate Change Is Real," *Huffington Post* (June 18, 2015) (http://www.huffingtonpost.com/2015/06/18/greg-gutfeld-pope-francis_n_7616156.html). Yet the sense that the problem is real and we have a responsibility to do something about it is growing; in fact, when the environmental group Urgenda (Urgent Agenda) sued the Dutch government, saying that failing to do

enough was a human rights violation, a Dutch court said the Dutch government must do more to reduce carbon dioxide emissions ("Dutch Court Orders Government to Cut More CO_2," *Science*, July 3, 2015).

It seems clear that something must be done, but what? How urgently? And with what aim? Can we stop it? Or must we adapt to it? In what ways? (See Bruce Guile and Raj Pandya, "Adapting to Global Warming: Four National Priorities," *Issues in Science and Technology*, Summer 2018.) Should we be trying to reduce or prevent human suffering? Or to avoid political conflicts? Or to protect the global economy—meaning standards of living, jobs, and businesses? The humanitarian and economic approaches are obviously connected, for protecting jobs certainly has much to do with easing or preventing suffering. However, these approaches can also conflict. In October 2009, the U.S. Government Accountability Office (GAO) released "Climate Change Adaptation: Strategic Federal Planning Could Help Government Officials Make More Informed Decisions" (GAO-10-113; http://www.gao.gov/products/GAO-10-113), which noted the need for multiagency coordination and strategic (long-term) planning, both of which are often resisted by bureaucrats and politicians. In 2014, the Climate Science Panel of the American Association for the Advancement of Science (AAAS) released "What We Know: The Reality, Risks and Response to Climate Change," which stressed in no uncertain terms that global warming and climate change are real, that they are caused by human activities, and that we face serious consequences if we do nothing. In October 2018, the IPCC reiterated the warning; see Matt McGrath, "Final Call to Save the World from 'Climate Catastrophe.'" BBC News (October 8, 2018) (https://www.bbc.com/news/science-environment-45775309).

When the U.N. Framework Convention on Climate Change met in Paris in December 2015, 195 of the world's nations promised to cut carbon emissions by specific amounts (Intended Nationally Determined Contributions, or INDCs). "For the agreement to have legal force, it must be ratified by at least 55 of the 195 countries that adopted it without objection Saturday. Those 55 countries must represent at least 55% of all global-warming emissions." After that, it will be essential to eliminate subsidies for the fossil fuel industries, impose carbon taxes, seek broader political consensus, and invest in renewable energy technologies such as solar power; see John D. Sutter, "Hooray for the Paris Agreement! Now What?" CNN.com (December 14, 2015) (http://www.cnn.com/2015/12/14/opinions/sutter-cop21-climate-5-things/). UN Secretary-General Ban Ki-Moon commented: "When historians look back on this day, they will say that global cooperation to secure a future safe from climate change took a dramatic new turn here in Paris. Today, we can look into the eyes of our children and grandchildren, and we can finally say, tell them that we have joined hands to bequeath a more habitable world to them and to future generations."

However, there remains resistance to the idea that global climate change is real, is caused by human activities, or poses any threat to the environment or human well-being. Most of the remaining critics of the reality of global warming are either employed by or funded by industries and nations that have a financial stake in resisting proposals for significant reductions in the release of greenhouse gases. Some fossil-fuel-industry funding is funneled through conservative organizations such as the Heartland Institute (http://heartland.org/), which in 2013 made news by spreading disinformation about scientific acceptance of global warming; see Phil Plait, "The Heartland Institute and the American Meteorological Society," *Slate* (December 10, 2013) (http://www.slate.com/blogs/bad_astronomy/2013/12/10/heartland_institute_sowing_global_warming_doubt.html?wpisrc=burger_bar).

Responding to this resistance, in 2017 the Trump Administration committed to withdrawing from the Paris Agreement (see Valerie Volcovici, "U.S. Submits Formal Notice of Withdrawal from Paris Climate Pact," Reuters, August 4, 2017; https://www.reuters.com/article/us-un-climate-usa-paris/u-s-submits-formal-notice-of-withdrawal-from-paris-climate-pact-idUSKBN1AK2FM). "President Donald Trump announced his decision to withdraw from the Paris deal in June, saying the accord would have cost America trillions of dollars, killed jobs, and hindered the oil, gas, coal and manufacturing industries."

In the YES selection, D. J. Wuebbles, D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, and T. K. Maycock, in Volume 1 of the National Climate Assessment, argue that, particularly given the tendency of climate models to underestimate the effects of carbon emissions (from large-scale combustion of fossil fuels and from deforestation), avoiding dangerous warming of the climate will require reducing net global CO_2 emissions. Volume 2 of the National Climate Assessment, released in November 2018, underlined that the potential effects of climate change on the U.S. economy and public health are dire (https://www.cnn.com/2018/11/23/health/climate-change-report-bn/index.html). In the NO selection, Kevin D. Dayaratna, Nicholas D. Loris, and David W. Kreutzer argue that trying to meet the requirements of the 2015 Paris Agreement by restricting the use of fossil fuels would harm several sectors of the U.S. economy with little if any benefit to the environment. By 2035, Gross Domestic Product (GDP) would lose $2.5 trillion, consumer electric bills would go up by 13 percent, and family income would lose $20,000.

YES

D. J. Wuebbles et al.

Climate Science Special Report: Fourth National Climate Assessment, Volume I

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Introduction

New observations and new research have increased our understanding of past, current, and future climate change since the Third U.S. National Climate Assessment (NCA3) was published in May 2014. This Climate Science Special Report (CSSR) is designed to capture that new information and build on the existing body of science in order to summarize the current state of knowledge and provide the scientific foundation for the Fourth National Climate Assessment (NCA4).

Since NCA3, stronger evidence has emerged for continuing, rapid, human-caused warming of the global atmosphere and ocean. This report concludes that "it is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century. For the warming over the last century, there is no convincing alternative explanation supported by the extent of the observational evidence."

The last few years have also seen record-breaking, climate-related weather extremes, the three warmest years on record for the globe, and continued decline in arctic sea ice. These trends are expected to continue in the future over climate (multidecadal) timescales. Significant advances have also been made in our understanding of extreme weather events and how they relate to increasing global temperatures and associated climate changes. Since 1980, the cost of extreme events for the United States has exceeded $1.1 trillion; therefore, better understanding of the frequency and severity of these events in the context of a changing climate is warranted.

Periodically taking stock of the current state of knowledge about climate change and putting new weather extremes, changes in sea ice, increases in ocean temperatures, and ocean acidification into context ensures that rigorous, scientifically-based information is available to inform dialogue and decisions at every level. This climate science report serves as the climate science foundation of the NCA4 and is generally intended for those who have a technical background in climate science. . . .

Global and U.S. Temperatures Continue to Rise

Long-term temperature observations are among the most consistent and widespread evidence of a warming planet. Temperature (and, above all, its local averages and extremes) affects agricultural productivity, energy use, human health, water resources, infrastructure, natural ecosystems, and many other essential aspects of society and the natural environment. Recent data add to the weight of evidence for rapid global-scale warming, the dominance of human causes, and the expected continuation of increasing temperatures, including more record-setting extremes.

Changes in Observed and Projected Global Temperature

The global, long-term, and unambiguous warming trend has continued during recent years. Since the last National Climate Assessment was published, 2014 became the warmest year on record globally; 2015 surpassed 2014 by a wide margin; and 2016 surpassed 2015. Sixteen of the warmest years on record for the globe occurred in the last 17 years (1998 was the exception).

- Global annual average temperature (as calculated from instrumental records over both land and oceans) has increased by more than 1.2°F (0.65°C) for the period 1986–2016 relative to 1901–1960; the linear regression change over the entire period from 1901–2016 is 1.8°F (1.0°C) (*very high confidence*). Longer-term climate records over past centuries and millennia indicate that average temperatures in recent decades over much of the world have been much higher, and have risen

Source: U.S. Global Change Research Program.

faster during this time period than at any time in the past 1,700 years or more, the time period for which the global distribution of surface temperatures can be reconstructed (*high confidence*).

- Many lines of evidence demonstrate that it is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century. Over the last century, there are no convincing alternative explanations supported by the extent of the observational evidence. Solar output changes and internal natural variability can only contribute marginally to the observed changes in climate over the last century, and there is no convincing evidence for natural cycles in the observational record that could explain the observed changes in climate. (*Very high confidence*)
- The *likely* range of the human contribution to the global mean temperature increase over the period 1951–2010 is 1.1° to 1.4°F (0.6° to 0.8°C), and the central estimate of the observed warming of 1.2°F (0.65°C) lies within this range (*high confidence*). This translates to a *likely* human contribution of 92%–123% of the observed 1951–2010 change. The *likely* contributions of natural forcing and internal variability to global temperature change over that period are minor (*high confidence*).
- Natural variability, including El Niño events and other recurring patterns of ocean–atmosphere interactions, impact temperature and precipitation, especially regionally, over timescales of months to years. The global influence of natural variability, however, is limited to a small fraction of observed climate trends over decades. (*Very high confidence*)
- Global climate is projected to continue to change over this century and beyond. The magnitude of climate change beyond the next few decades will depend primarily on the amount of greenhouse (heat-trapping) gases emitted globally and on the remaining uncertainty in the sensitivity of Earth's climate to those emissions (very *high confidence*). With significant reductions in the emissions of greenhouse gases, the global annually averaged temperature rise could be limited to 3.6°F (2°C) or less. Without major reductions in these emissions, the increase in annual average global temperatures relative to pre-industrial times could reach 9°F (5°C) or more by the end of this century.
- If greenhouse gas concentrations were stabilized at their current level, existing concentrations would commit the world to at least an additional 1.1°F (0.6°C) of warming over this century relative to the last few decades (*high confidence* in continued warming, *medium confidence* in amount of warming).

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Changes in Observed and Projected U.S. Temperature

Annual average temperature over the contiguous United States has increased by 1.8°F (1.0°C) for the period 1901–2016 and is projected to continue to rise. (*Very high confidence*).

- Annual average temperature over the contiguous United States has increased by 1.2°F (0.7°C) for the period 1986–2016 relative to 1901–1960 and by 1.8°F (1.0°C) based on a linear regression for the period 1901–2016 (*very high confidence*). Surface and satellite data are consistent in their depiction of rapid warming since 1979 (*high confidence*). Paleo-temperature evidence shows that recent decades are the warmest of the past 1,500 years (*medium confidence*).
- Annual average temperature over the contiguous United States is projected to rise (*very high confidence*). Increases of about 2.5°F (1.4°C) are projected for the period 2021–2050 relative to the average from 1976–2005 in all RCP scenarios, implying recent record-setting years may be "common" in the next few decades (*high confidence*). Much larger rises are projected by late century . . .
- In the United States, the urban heat island effect results in daytime temperatures 0.9°–7.2°F (0.5°–4.0°C) higher and nighttime temperatures 1.8°–4.5°F (1.0°–2.5°C) higher in urban areas than in rural areas, with larger temperature differences in humid regions (primarily in the eastern United States) and in cities with larger and denser populations. The urban heat island effect will strengthen in the future as the structure and spatial extent as well as population density of urban areas change and grow (*high confidence*).

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Many Temperature and Precipitation Extremes Are Becoming More Common

Temperature and precipitation extremes can affect water quality and availability, agricultural productivity, human health, vital infrastructure, iconic ecosystems and species, and the likelihood of disasters. Some extremes have already become more frequent, intense, or of longer duration, and many extremes are expected to continue to increase or worsen, presenting substantial challenges for built, agricultural, and natural systems. Some storm types such as hurricanes, tornadoes, and winter storms are

also exhibiting changes that have been linked to climate change, although the current state of the science does not yet permit detailed understanding.

Observed Changes in Extremes

There have been marked changes in temperature extremes across the contiguous United States. The number of high temperature records set in the past two decades far exceeds the number of low temperature records. (*Very high confidence*)

- The frequency of cold waves has decreased since the early 1900s, and the frequency of heat waves has increased since the mid-1960s (the Dust Bowl era of the 1930s remains the peak period for extreme heat in the United States). (*Very high confidence*)
- The frequency and intensity of extreme heat and heavy precipitation events are increasing in most continental regions of the world (*very high confidence*). These trends are consistent with expected physical responses to a warming climate. Climate model studies are also consistent with these trends, although models tend to underestimate the observed trends, especially for the increase in extreme precipitation events (*very high confidence* for temperature, *high confidence* for extreme precipitation).

Heavy precipitation events in most parts of the United States have increased in both intensity and frequency since 1901 (*high confidence*). There are important regional differences in trends, with the largest increases occurring in the northeastern United States (*high confidence*).

. . .

- Recent droughts and associated heat waves have reached record intensity in some regions of the United States; however, by geographical scale and duration, the Dust Bowl era of the 1930s remains the benchmark drought and extreme heat event in the historical record. (*Very high confidence*)
- Northern Hemisphere spring snow cover extent, North America maximum snow depth, snow water equivalent in the western United States, and extreme snowfall years in the southern and western United States have all declined, while extreme snowfall years in parts of the northern United States have increased. (*Medium confidence*).
- There has been a trend toward earlier snowmelt and a decrease in snowstorm frequency on the southern margins of climatologically snowy areas (*medium confidence*). Winter storm tracks have shifted northward since 1950 over the Northern Hemisphere (*medium confidence*). Potential linkages between the frequency and intensity of severe winter storms in the United States and accelerated warming in the Arctic have been postulated, but they are complex, and, to some extent, contested, and confidence in the connection is currently *low.*
- Tornado activity in the United States has become more variable, particularly over the 2000s, with a decrease in the number of days per year with tornadoes and an increase in the number of tornadoes on these days (*medium confidence*). Confidence in past trends for hail and severe thunderstorm winds, however, is *low.*

Projected Changes in Extremes

- The frequency and intensity of extreme high temperature events are *virtually certain* to increase in the future as global temperature increases (*high confidence*). Extreme precipitation events will *very likely* continue to increase in frequency and intensity throughout most of the world (*high confidence*). Observed and projected trends for some other types of extreme events, such as floods, droughts, and severe storms, have more variable regional characteristics.

Extreme temperatures in the contiguous United States are projected to increase even more than average temperatures (*very high confidence*).

- Both extremely cold days and extremely warm days are expected to become warmer. Cold waves are predicted to become less intense while heat waves will become more intense. The number of days below freezing is projected to decline while the number above 90°F will rise. *(Very high confidence)*
- The frequency and intensity of heavy precipitation events in the United States are projected to continue to increase over the 21st century (*high confidence*). There are, however, important regional and seasonal differences in projected changes in total precipitation: the northern United States, including Alaska, is projected to receive more precipitation in the winter and spring, and parts of the southwestern United States are projected to receive less precipitation in the winter and spring (*medium confidence*).
- The frequency and severity of landfalling "atmospheric rivers" on the U.S. West Coast (narrow

streams of moisture that account for 30%–40% of the typical snowpack and annual precipitation in the region and are associated with severe flooding events) will increase as a result of increasing evaporation and resulting higher atmospheric water vapor that occurs with increasing temperature. (*Medium confidence*)

- Projections indicate large declines in snowpack in the western United States and shifts to more precipitation falling as rain than snow in the cold season in many parts of the central and eastern United States (*high confidence*).
- Substantial reductions in western U.S. winter and spring snowpack are projected as the climate warms. Earlier spring melt and reduced snow water equivalent have been formally attributed to human-induced warming (*high confidence*) and will *very likely* be exacerbated as the climate continues to warm (*very high confidence*). Under higher scenarios, and assuming no change to current water resources management, chronic, long-duration hydrological drought is increasingly possible by the end of this century (*very high confidence*).

Future decreases in surface soil moisture from human activities over most of the United States are *likely* as the climate warms under the higher scenarios. (*Medium confidence*)

- The human effect on recent major U.S. droughts is complicated. Little evidence is found for a human influence on observed precipitation deficits, but much evidence is found for a human influence on surface soil moisture deficits due to increased evapotranspiration caused by higher temperatures. (*High confidence*)
- The incidence of large forest fires in the western United States and Alaska has increased since the early 1980s (*high confidence*) and is projected to further increase in those regions as the climate warms, with profound changes to certain ecosystems (*medium confidence*).
- Both physics and numerical modeling simulations generally indicate an increase in tropical cyclone intensity in a warmer world, and the models generally show an increase in the number of very intense tropical cyclones. For Atlantic and eastern North Pacific hurricanes and western North Pacific typhoons, increases are projected in precipitation rates (*high confidence*) and intensity (*medium confidence*). The frequency of the most intense of these storms is projected to increase in the Atlantic and western North Pacific (*low confidence*) and in the eastern North Pacific (*medium confidence*).

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Oceans Are Rising, Warming, and Becoming More Acidic

Oceans occupy two-thirds of the planet's surface and host unique ecosystems and species, including those important for global commercial and subsistence fishing. Understanding climate impacts on the ocean and the ocean's feedbacks to the climate system is critical for a comprehensive understanding of current and future changes in climate.

Global Ocean Heat

The world's oceans have absorbed about 93% of the excess heat caused by greenhouse gas warming since the mid-20th century, making them warmer and altering global and regional climate feedbacks. (*Very high confidence*)

- Ocean heat content has increased at all depths since the 1960s and surface waters have warmed by about 1.3° ± 0.1°F (0.7° ± 0.08°C) per century globally since 1900 to 2016. Under higher scenarios, a global increase in average sea surface temperature of 4.9° ± 1.3°F (2.7° ± 0.7°C) is projected by 2100. (*Very high confidence*).

Global and Regional Sea Level Rise

Global mean sea level (GMSL) has risen by about 7–8 inches (about 16–21 cm) since 1900, with about 3 of those inches (about 7 cm) occurring since 1993 (*very high confidence*).

- Human-caused climate change has made a substantial contribution to GMSL rise since 1900 (*high confidence*), contributing to a rate of rise that is greater than during any preceding century in at least 2,800 years (*medium confidence*).
- Relative to the year 2000, GMSL is *very likely* to rise by 0.3–0.6 feet (9–18 cm) by 2030, 0.5–1.2 feet (15–38 cm) by 2050, and 1.0–4.3 feet (30–130 cm) by 2100 (*very high confidence* in lower bounds; *medium confidence* in upper bounds for 2030 and 2050; *low confidence* in upper bounds for 2100). Future emissions pathways have little effect on projected GMSL rise in the first half of the century, but significantly affect projections for the second half of the century (*high confidence*).

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- Emerging science regarding Antarctic ice sheet stability suggests that, for higher scenarios, a GMSL rise exceeding 8 feet (2.4 m) by 2100 is physically possible, although the probability of such an extreme outcome cannot currently be assessed. Regardless of emission pathway, it is *extremely likely* that GMSL rise will continue beyond 2100 (*high confidence*).
- Relative sea level rise in this century will vary along U.S. coastlines due, in part, to changes in Earth's gravitational field and rotation from melting of land ice, changes in ocean circulation, and vertical land motion (*very high confidence*). For almost all future GMSL rise scenarios, relative sea level rise is *likely* to be greater than the global average in the U.S. Northeast and the western Gulf of Mexico. In intermediate and low GMSL rise scenarios, relative sea level rise is *likely* to be less than the global average in much of the Pacific Northwest and Alaska. For high GMSL rise scenarios, relative sea level rise is *likely* to be higher than the global average along all U.S. coastlines outside Alaska. Almost all U.S. coastlines experience more than global mean sea level rise in response to Antarctic ice loss, and thus would be particularly affected under extreme GMSL rise scenarios involving substantial Antarctic mass loss (*high confidence*).

Coastal Flooding

- As sea levels have risen, the number of tidal floods each year that cause minor impacts (also called "nuisance floods") have increased 5- to 10-fold since the 1960s in several U.S. coastal cities (*very high confidence*). Rates of increase are accelerating in over 25 Atlantic and Gulf Coast cities (*very high confidence*). Tidal flooding will continue increasing in depth, frequency, and extent this century (*very high confidence*).
- Assuming storm characteristics do not change, sea level rise will increase the frequency and extent of extreme flooding associated with coastal storms, such as hurricanes and nor'easters (*very high confidence*). A projected increase in the intensity of hurricanes in the North Atlantic (*medium confidence*) could increase the probability of extreme flooding along most of the U.S. Atlantic and Gulf Coast states beyond what would be projected based solely on relative sea level rise. However, there is *low confidence* in the projected increase in frequency of intense Atlantic hurricanes, and the associated flood risk amplification, and flood effects could be offset or amplified by such factors, such as changes in overall storm frequency or tracks.

. . .

Global and Regional Ocean Acidification

The world's oceans are currently absorbing more than a quarter of the CO_2 emitted to the atmosphere annually from human activities, making them more acidic (*very high confidence*), with potential detrimental impacts to marine ecosystems.

- Higher-latitude systems typically have a lower buffering capacity against changing acidity, exhibiting seasonally corrosive conditions sooner than low-latitude systems. The rate of acidification is unparalleled in at least the past 66 million years (*medium confidence*). Under the higher scenario, the global average surface ocean acidity is projected to increase by 100% to 150% (*high confidence*).
- Acidification is regionally greater than the global average along U.S. coastal systems as a result of upwelling (e.g., in the Pacific Northwest) (*high confidence*), changes in freshwater inputs (e.g., in the Gulf of Maine) (*medium confidence*), and nutrient input (e.g., in urbanized estuaries) (*high confidence*).

Ocean Oxygen

- Increasing sea surface temperatures, rising sea levels, and changing patterns of precipitation, winds, nutrients, and ocean circulation are contributing to overall declining oxygen concentrations at intermediate depths in various ocean locations and in many coastal areas. Over the last half century, major oxygen losses have occurred in inland seas, estuaries, and in the coastal and open ocean (*high confidence*). Ocean oxygen levels are projected to decrease by as much as 3.5% under the higher scenario by 2100 relative to preindustrial values (*high confidence*).

Climate Change in Alaska and across the Arctic Continues to Outpace Global Climate Change

Residents of Alaska are on the front lines of climate change. Crumbling buildings, roads, and bridges and eroding shorelines are commonplace. Accelerated melting of multiyear sea ice cover, mass loss from the Greenland Ice Sheet, reduced snow cover, and permafrost thawing

are stark examples of the rapid changes occurring in the Arctic. Furthermore, because elements of the climate system are interconnected, changes in the Arctic influence climate conditions outside the Arctic.

Arctic Temperature Increases

Annual average near-surface air temperatures across Alaska and the Arctic have increased over the last 50 years at a rate more than twice as fast as the global average temperature. (*Very high confidence*)

- Rising Alaskan permafrost temperatures are causing permafrost to thaw and become more discontinuous; this process releases additional carbon dioxide and methane resulting in additional warming (*high confidence*). The overall magnitude of the permafrost-carbon feedback is uncertain; however, it is clear that these emissions have the potential to compromise the ability to limit global temperature increases.
- Atmospheric circulation patterns connect the climates of the Arctic and the contiguous United States. Evidenced by recent record warm temperatures in the Arctic and emerging science, the midlatitude circulation has influenced observed arctic temperatures and sea ice (*high confidence*). However, confidence is low regarding whether or by what mechanisms observed arctic warming may have influenced the midlatitude circulation and weather patterns over the continental United States. The influence of arctic changes on U.S. weather over the coming decades remains an open question with the potential for significant impact.

Arctic Land Ice Loss

- Arctic land ice loss observed in the last three decades continues, in some cases accelerating (*very high confidence*). It is *virtually certain* that Alaska glaciers have lost mass over the last 50 years, with each year since 1984 showing an annual average ice mass less than the previous year. Over the satellite record, average ice mass loss from Greenland was –269 Gt per year between April 2002 and April 2016, accelerating in recent years (*high confidence*).

Arctic Sea Ice Loss

Since the early 1980s, annual average arctic sea ice has decreased in extent between 3.5% and 4.1% per decade, has become thinner by between 4.3 and 7.5 feet, and is melting at least 15 more days each year. September sea ice extent has decreased between 10.7% and 15.9% per decade. (*Very high confidence*)

- Arctic sea ice loss is expected to continue through the 21st century, *very likely* resulting in nearly sea ice-free late summers by the 2040s (*very high confidence*).
- It is *very likely* that human activities have contributed to observed arctic surface temperature warming, sea ice loss, glacier mass loss, and northern hemisphere snow extent decline (*high confidence*).

. . .

Limiting Globally Averaged Warming to 2°C (3.6°F) Will Require Major Reductions in Emissions

Human activities are now the dominant cause of the observed trends in climate. For that reason, future climate projections are based on scenarios of how human activities will continue to affect the climate over the remainder of this century and beyond. There remains significant uncertainty about future emissions due to changing economic, political, and demographic factors. For that reason, this report quantifies possible climate changes for a broad set of plausible future scenarios through the end of the century.

The observed increase in global carbon emissions over the past 15–20 years has been consistent with higher scenarios (*very high confidence*). In 2014 and 2015, emission growth rates slowed as economic growth became less carbon-intensive (*medium confidence*). Even if this slowing trend continues, however, it is not yet at a rate that would limit the increase in the global average temperature to well below 3.6°F (2°C) above preindustrial levels (*high confidence*).

- Global mean atmospheric carbon dioxide (CO_2) concentration has now passed 400 ppm, a level that last occurred about 3 million years ago, when global average temperature and sea level were significantly higher than today (*high confidence*). Continued growth in CO_2 emissions over this century and beyond would lead to an atmospheric concentration not experienced in tens of millions of years (*medium confidence*). The present-day emissions rate of nearly 10 GtC per year suggests that there is no climate analog for this century any time in at least the last 50 million years (*medium confidence*).

- Warming and associated climate effects from CO_2 emissions persist for decades to millennia. In the near-term, changes in climate are determined by past and present greenhouse gas emissions modified by natural variability. Reducing net emissions of CO_2 is necessary to limit near-term climate change and long-term warming. Other greenhouse gases (e.g., methane) and black carbon aerosols exert stronger warming effects than CO_2 on a per ton basis, but they do not persist as long in the atmosphere; therefore, mitigation of non-CO_2 species contributes substantially to near-term cooling benefits but cannot be relied upon for ultimate stabilization goals. (*Very high confidence*)

Choices made today will determine the magnitude of climate change risks beyond the next few decades.

- Stabilizing global mean temperature to less than 3.6°F (2°C) above preindustrial levels requires substantial reductions in net global CO_2 emissions prior to 2040 relative to present-day values before 2040 and likely requires net emissions to become zero or possibly negative later in the century. After accounting for the temperature effects of non-CO_2 species, cumulative global CO_2 emissions must stay below about 800 GtC in order to provide a two-thirds likelihood of preventing 3.6°F (2°C) of warming. Given estimated cumulative emissions since 1870, no more than approximately 230 GtC may be emitted in the future in order to remain under this temperature limit. Assuming global emissions are equal to or greater than those consistent with [a moderate] scenario, this cumulative carbon threshold would be exceeded in approximately two decades.
- Achieving global greenhouse gas emissions reductions before 2030 consistent with targets and actions announced by governments in the lead up to the 2015 Paris climate conference would hold open the possibility of meeting the long-term temperature goal of limiting global warming to 3.6°F (2°C) above preindustrial levels, whereas there would be virtually no chance if net global emissions followed a pathway well above those implied by country announcements. Actions in the announcements are, by themselves, insufficient to meet a 3.6°F (2°C) goal; the likelihood of achieving that depends strongly on the magnitude of global emissions reductions after 2030. (*High confidence*)
- Climate intervention or geoengineering strategies such as solar radiation management are measures that attempt to limit or reduce global temperature increases. Further assessments of the technical feasibilities, costs, risks, co-benefits, and governance challenges of climate intervention or geoengineering strategies, which are as yet unproven at scale, are a necessary step before judgments about the benefits and risks of these approaches can be made with high confidence. (*High confidence*)
- In recent decades, land-use and land-cover changes have turned the terrestrial biosphere (soil and plants) into a net "sink" for carbon (drawing down carbon from the atmosphere), and this sink has steadily increased since 1980 (*high confidence*). Because of the uncertainty in the trajectory of land cover, the possibility of the land becoming a net carbon source cannot be excluded (*very high confidence*).

There Is a Significant Possibility for Unanticipated Changes

Humanity's effect on the Earth system, through the large-scale combustion of fossil fuels and widespread deforestation and the resulting release of carbon dioxide (CO_2) into the atmosphere, as well as through emissions of other greenhouse gases and radiatively active substances from human activities, is unprecedented. There is significant potential for humanity's effect on the planet to result in unanticipated surprises and a broad consensus that the further and faster the Earth system is pushed towards warming, the greater the risk of such surprises.

There are at least two types of potential surprises: *compound events*, where multiple extreme climate events occur simultaneously or sequentially (creating greater overall impact), and *critical threshold* or *tipping point events*, where some threshold is crossed in the climate system (that leads to large impacts). The probability of such surprises—some of which may be abrupt and/or irreversible—as well as other more predictable but difficult-to-manage impacts, increases as the influence of human activities on the climate system increases.

Unanticipated and difficult or impossible-to-manage changes in the climate system are possible throughout the next century as critical thresholds are crossed and/or multiple climate-related extreme events occur simultaneously.

- Positive feedbacks (self-reinforcing cycles) within the climate system have the potential to accelerate human-induced climate change and even shift the Earth's climate system, in part or in whole, into new states that are very different from those

experienced in the recent past (for example, ones with greatly diminished ice sheets or different large-scale patterns of atmosphere or ocean circulation). Some feedbacks and potential state shifts can be modeled and quantified; others can be modeled or identified but not quantified; and some are probably still unknown. (*Very high confidence* in the potential for state shifts and in the incompleteness of knowledge about feedbacks and potential state shifts).

- The physical and socioeconomic impacts of compound extreme events (such as simultaneous heat and drought, wildfires associated with hot and dry conditions, or flooding associated with high precipitation on top of snow or waterlogged ground) can be greater than the sum of the parts (*very high confidence*). Few analyses consider the spatial or temporal correlation between extreme events.
- While climate models incorporate important climate processes that can be well quantified, they do not include all of the processes that can contribute to feedbacks, compound extreme events, and abrupt and/or irreversible changes. For this reason, future changes outside the range projected by climate models cannot be ruled out (*very high confidence*). Moreover, the systematic tendency of climate models to underestimate temperature change during warm paleoclimates suggests that climate models are more likely to underestimate than to overestimate the amount of long-term future change (*medium confidence*).

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NO

Consequences of Paris Protocol: Devastating Economic Costs, Essentially Zero Environmental Benefits

During the 2015 United Nations Climate Change Conference in Paris, president Barack Obama met with world leaders from around the globe to discuss plans to combat climate change. The general consensus from the summit was that the use of natural resources, such as coal, oil, and natural gas—which provide 80 percent of the world's energy needs—should be avoided. Furthermore, industrialized, rich countries should pay for poor countries to build more renewable power and address climate change. In effect, the framework is a push for *un*-development for the industrialized world and a major obstacle for growth for the developing world. The economic impact of instituting the regulations associated with the Paris agreement will be severe. Policies that restrict the use of carbon-based energy in America will kill jobs and stifle economic growth. Regardless of one's opinions on the impact of carbon dioxide (CO_2) emissions on global temperatures the economic sacrifices will generate a negligible impact on global temperatures.

The Climate Summit in Paris and Domestic Regulations

Leaders from around the world convened at the 2015 U.N. Climate Change Conference in Paris to discuss how to combat climate change. President Obama began the summit by addressing the attendees: "For all the challenges we face, the growing threat of climate change could define the contours of this century more dramatically than any other." The goal of the conference was for the various countries attending to reach an agreement to limit CO_2 emissions in order to reduce global temperatures.

A central element to the U.S. commitment as part of the Paris agreement is the intended nationally determined contribution (INDC) to reduce greenhouse gas emissions. Countries must make specific, measurable commitments to curb carbon dioxide emissions and submit them to the United Nations Framework Convention on Climate Change (UNFCCC) secretariat. The Obama Administration's INDC aims to reduce U.S. greenhouse gas emissions by 26 percent to 28 percent below 2005 levels by the year 2025. While the INDC is non-binding and the Administration emphasizes that the U.S. "does not intend to utilize international market mechanisms," the plan outlines the litany of domestic regulations that the Administration proposed and implemented during President Obama's time in office so far, including:

- Carbon dioxide regulations for new and existing power plants. Combined, these two regulations serve as a major component of the Administration's global warming agenda.
- Fuel-efficiency and greenhouse gas regulations for light and heavy-duty vehicles.
- Energy-efficiency regulations for commercial and residential buildings as well as appliances.
- Environmental Protection Agency (EPA)-approved alternatives to hydrochlorofluorocarbons.
- Methane regulations for landfills and the oil and gas sector.
- Executive orders to reduce greenhouse gas emissions by the federal government.

The Economic Impact of the Plan

Energy is a key building block for economic opportunity. Carbon-dioxide-emitting fuels, such as coal, oil, and natural gas, provided 87 percent of America's energy needs in the past decade, and have been the overwhelming supplier for over a century. Restricting the use of conventional energy sources as laid out by the Obama Administration's INDC will significantly harm the U.S. economy. Americans feel the pain of higher energy prices directly, but also indi-

Dayaratna, Kevin D., Nicolas D. Loris, and David W. Kreutzer. "Consequences of Paris Protocol: Devastating Economic Costs, Essentially Zero Environmental Benefits." Heritage Foundation. April 13, 2016.

rectly through almost all of the goods and services they buy, because energy is a necessary component of production and service. Higher energy prices will disproportionately hurt the poorest Americans, who spend the highest percentage of their budget on energy bills.

Companies will pass higher costs on to consumers or absorb the costs, which prevents hiring and new investment. As prices rise, consumers buy less, and companies will drop employees, close entirely, or move to other countries where the cost of doing business is lower. The result is fewer opportunities for American workers, lower incomes, less economic growth, and higher unemployment. In order to estimate the impact on the economy of the Paris protocol policies, we estimated the economic impact of a tax equivalent to the EPA's annual estimates of the social cost of carbon (SCC) in a manner similar to one of our previous studies. Since the crude oil export ban has been lifted, however, we incorporated this change into our simulations of both current policy as well as the Paris agreement. The SCC purports to quantify the economic damages associated with a single metric ton of carbon dioxide emissions over the course of a 300-year time horizon. At their core, these models are fundamentally flawed because their damage functions are arbitrary. Heritage research has also found that these models are extremely sensitive to reasonable changes in assumptions; in fact, under some assumptions one of the models provides a negative SCC, suggesting net economic benefits to carbon dioxide emissions. The Administration insists on using these models anyway.

We used the Heritage Energy Model (HEM), a clone of the National Energy Modeling System 2015 Full release (NEMS), to quantify the economic impact of instituting the regulations associated with the policies stemming from the Paris agreement. We did so by modeling a $36 carbon tax increasing in conjunction with the EPA's annual estimates of the SCC. Modeling tax changes as a substitute for quantifying the economic impact of regulatory proposals is a widely accepted practice. To negate the analytical impacts of a tax's income transfer, 100 percent of carbon-tax revenue is returned to taxpayers. Policies adapted from domestic regulations emphasized in the Paris agreement will affect a variety of aspects of the American economy. As a result of the plan, one can expect that by 2035, there will be:

- An overall average shortfall of nearly 400,000 jobs;
- An average manufacturing shortfall of over 200,000 jobs;
- A total income loss of more than $20,000 for a family of four;
- An aggregate gross domestic product (GDp) loss of over $2.5 trillion; and
- increases in household electricity expenditures between 13 percent and 20 percent. . . .

. . . The impact of the Paris agreement on manufacturing is quite devastating. In terms of overall employment, the agreement ends up killing more than 300,000 jobs by 2035.

The impact on personal income that an average family of four would incur is also quite significant, especially toward the end of the next decade. . . .

As global warming regulations stifle the use of the most efficient and inexpensive forms of electricity, businesses as well as households will incur higher electricity costs. . . .

Negligible Benefits

In his 2015 State of the Union Address, President Obama claimed that "no challenge—no challenge—poses a greater threat to future generations than climate change." In that case, the president's policies have missed their mark. Regardless of one's opinions on the degree to which climate change is occurring, there is compelling evidence that policies like those resulting from the Paris agreement will have little impact on global temperatures. In fact, using the Model for the Assessment of Greenhouse Gas Induced Climate Change developed by researchers at the National Center for Atmospheric Research, even if all carbon dioxide emissions in the United States were effectively eliminated, there would be *less than two-tenths of a degree Celsius reduction in global temperatures*. In fact, the entire industrialized world could cut carbon emissions down to zero, and the climate impact would still be less than four tenths of a degree Celsius in terms of averted warming by the year 2100. In addition, the various country-specific emissions targets for all the countries in the Paris agreement do not offer much hope for climate impact even if all the countries comply perfectly with their promised cuts. History, however, gives little confidence that such compliance will even occur. For instance, China is building 350 coal-fired power plants, and has plans for another 800. Further, if China is not addressing its harmful smog and poor water quality, there is justification for doubting its commitment to addressing global warming. Many developing countries have shown an unwillingness to curb economic growth to reduce greenhouse gas emissions.

Conclusion

Heritage's clone of the Energy information Administration's energy model shows that restricting energy production to meet targets like those of the Paris agreement will significantly harm the U.S. economy. Bureaucratically administered mandates, taxes, and special interest subsidies will drive family incomes down by thousands of dollars per year, drive up energy costs, and eliminate hundreds of thousands of jobs. All of these costs would be incurred to achieve only trivial and theoretical impacts on global warming. Policymakers should therefore make every effort possible to prevent implementation of these harmful environmental regulations.

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EXPLORING THE ISSUE

Is It Necessary to Reduce Carbon Emissions to Fight Global Warming?

Critical Thinking and Reflection

1. Will reducing carbon dioxide emissions damage the U.S. economy more than letting global warming do its thing?
2. In what ways will global warming affect your future life?
3. Do we have a responsibility to avoid damaging the environment in ways that will harm future generations?

Is There Common Ground?

Both sides in this issue agree that one of the major methods suggested for controlling global warming involves controlling carbon dioxide emissions. They differ in whether this will work and whether it will impose on society an unacceptable financial burden.

1. Is it appropriate to consider the costs and benefits of controlling carbon dioxide emissions only in terms of the 21st century?
2. Given the uncertainties in the conclusions about future impacts, should we even try to avoid those impacts?
3. Considering future sea level rise, might global warming actually be good for the economy?

Additional Resources

National Research Council, *Advancing the Science of Climate Change* (http://www.nap.edu/catalog.php?record_id=12782) (May 2010).

National Research Council, *Limiting the Magnitude of Future Climate Change* (http://www.nap.edu/catalog.php?record_id=12785) (May 2010).

National Research Council, *Adapting to the Impacts of Climate Change* (http://www.nap.edu/catalog.php?record_id=12783) (May 2010).

Roger Pielke, Jr., "Opening Up the Climate Policy Envelope," *Issues in Science and Technology* (Summer 2018).

Nicholas Stern, *Stern Review: The Economics of Climate Change*, Executive Summary, October 30, 2006 (http://webarchive.nationalarchives.gov.uk/20080910140413/http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm).

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Climate Change

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Intergovernmental Panel on Climate Change

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The National Renewable Energy Laboratory

https://www.nrel.gov/

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ISSUE

Is Home Solar the Wave of the Future?

YES: Peter Bronski et al., from "The Economics of Grid Defection," Rocky Mountain Institute (2014)

NO: Peter Kind, from "Disruptive Challenges: Financial Implications and Strategic Responses to a Changing Retail Electric Business," Edison Electric Institute (2013)

Learning Outcomes

After reading this issue, you will be able to:

- Explain the benefits of home solar power.
- Explain why electric utilities see home solar as a threat.
- Explain why home solar power users still need the electric utility's infrastructure (or grid).
- Discuss ways utilities can raise the money to maintain the infrastructure (or grid).

ISSUE SUMMARY

YES: Peter Bronski et al., of the Rocky Mountain Institute (RMI) argue that the combination of home solar power with storage technologies such as batteries offer to make the electricity grid optional for many consumers, perhaps as early as the 2020s. Utilities have an opportunity to exploit the spread of "distributed electricity generation" to provide a robust, reliable electricity supply.

NO: Peter Kind, executive director of Energy Infrastructure Advocates, argues that increased interest in "distributed energy resources" such as home solar power and energy efficiency, among other factors, is threatening to reduce revenue and increase costs for electrical utilities. In order to protect investors and capital availability, electrical utilities must consider new charges for customers who reduce their electricity usage, decreased payments to homeowners using net metering, and even new charges to users of "distributed energy resources" to offset "stranded costs" (such as no longer needed power plants).

We have known how to generate electricity from the sun for many years. One technique that has actually been put to use by electric utilities uses mirrors to concentrate sunlight on a boiler, generate steam, and spin the turbines of electrical generators. The largest and most recent example is the Ivanpah solar farm in California's Mojave Desert; it was designed to produce over a million megawatt-hours of electricity per year, but weather and start-up issues have affected its performance (see Pete Danko, "At Ivanpah Solar Power Plant, Energy Production Falling Well Short of Expectations," *Breaking Energy*, October 29, 2014; http://breakingenergy.com/2014/10/29/at-ivanpah-solar-power-plant-energy-production-falling-well-short-of-expectations/).

A more direct use of sunlight to generate electricity relies on solar cells. They can be deployed anywhere a flat surface faces the sun—on rooves, on free-standing frameworks, and even on roads (the first example is a portion of a bike path in the Netherlands—see http://www.npr.org/blogs/thetwo-way/2014/11/10/363023227/solar-bike-path-opens-this-week-in-the-netherlands. Of course, no solar power system can generate electricity when the sun isn't shining, as at night or in cloudy

weather. An effective solar power system therefore needs backup electricity sources or storage mechanisms such as batteries. It could also be an interconnected system spread out across multiple time zones. One solution is the "smart grid" that has been under discussion for the last few years. Russell Kay, "The Smart Grid," *Computerworld* (May 11, 2009), describes it as a more advanced and efficient version of the current grid (the network of power plants, power lines, substations, and computerized control stations that controls the distribution of electricity even when disrupted by storms, power plant failures, and other problems), with digital controls to coordinate a host of small and intermittent electricity sources, such as home solar and wind power. See also Mike Martin, "The Great Green Grid," *E Magazine* (July–August 2010).

As the price of solar cells has come down, their popularity has been increasing, aided by federal corporate investment credits and federal and state tax breaks, and even local subsidies, for homeowners. It now seems entirely possible that the technology could become very widely used. James M. Higgins, "Your Solar-Powered Future: It's Closer than You Thought," *The Futurist* (May–June 2009), tells us that "Ten years from now, power generation will be much more widely distributed. Homes and businesses alike will install solar-energy conversion systems for most—if not all—of their electrical needs." Ken Zweibel, James Mason, and Vasilis Fthenakis, "A Solar Grand Plan," *Scientific American* (January 2008), believe that with appropriate investment, solar can replace most or all conventional electricity generation; Mark Z. Jacobson and Mark A. Delucchi, "A Path to Sustainable Energy by 2030," *Scientific American* (November 2009), think it will take longer. But the process is already under way. At present, businesses such as SolarCity (http://www.solarcity.com/), Sungevity (http://www.sungevity.com/), Sunrun (http://www.sunrun.com/), and Vivint (http://www.vivintsolar.com/) offer consumers the chance to let the company install solar cells on home rooftops, use some of the electricity generated, and sell the rest to utilities. People can also buy solar systems outright, with or without battery backup.

In November 2014, Deutsche Bank released a report on Vivint which predicted that the cost of rooftop solar electricity, already equal to or less than the cost of coal and oil-fueled electricity in ten states of the United States, would match or beat those costs in all 50 states by 2016. And the technology is expected to get even cheaper. See Lucas Mearian, "Rooftop Solar Electricity on Pace to Beat Coal, Oil," *Computerworld* (November 18, 2014) (http://www.computerworld.com/article/2848875/rooftop-solar-electricity-on-pace-to-beat-coal-oil.html).

It is not surprising that consumers find rooftop solar appealing. It's already cheaper than utility electricity in some places, some states have implemented "net metering" (meaning that a homeowner who generates more electricity than needed can sell it to the local power company, and the power company has to buy it), in operation it does not emit greenhouse gases and thus contribute to global warming, and it offers independence from external systems. It also offers advantages to utilities, for if rooftop solar spreads, there will be less need to build huge new power plants. If homeowners opt to combine rooftop solar with battery storage systems, the need for poles and wires declines as well. However, that need does not seem likely to go away entirely; solar power depends on a steady supply of sunshine, and battery systems have finite capacity. Given a long spell of cloudy weather, people would still need the power company.

But, according to David Biello, "Solar Wars," *Scientific American* (November 2014), the trend is already worrying electrical utilities. As more and more states mandate that utilities buy surplus electricity from home providers and as home providers proliferate, the utilities see a day coming when their profits will be seriously affected. Worse yet, regulators require them to maintain the electrical grid—poles, wires, transformers, and power plants—that currently supplies everyone with a dependable supply of electricity and to recoup the costs by charging their customers. If they lose customers, they must either charge the remaining customers more or find a way to bill noncustomers. In Florida, local government seems prepared to help by preventing people from disconnecting from the grid (http://www.nbc-2.com/story/24790572/cape-woman-living-of-the-grid-challenged-by-city#.VGjCsMltgpE). In Hawaii, utilities restrict or block rooftop solar. In other states, they are pushing hard to do the same.

Is home solar power really a threat to utilities? If you take the stance that utilities have a right to keep making money and attracting investors the same way they have for the last century, perhaps it is. But if you think that home solar power offers ways to retool their business model, perhaps not. In the YES selection, Peter Bronski et al. of the Rocky Mountain Institute argue that the combination of home solar power with storage technologies such as batteries offers to make the electricity grid optional for many consumers, perhaps as early as the 2020s. Utilities have opportunities to exploit the spread of "distributed electricity generation" to provide a robust, reliable

electricity supply. The authors are working on a second report about the implications of these "disruptive opportunities" for utility business models. In the NO selection, Peter Kind, executive director of Energy Infrastructure Advocates, argues that increased interest in "distributed energy resources" such as home solar power and energy efficiency, among other factors, is threatening to reduce revenue and increase costs for electrical utilities. In order to protect investors and capital availability, electrical utilities must consider new charges for customers who reduce their electricity usage, decreased payments to homeowners using net metering, and even new charges to users of "distributed energy resources" to offset "stranded costs" (such as no longer needed power plants).

YES

Peter Bronski et al.

The Economics of Grid Defection

Introduction

Utilities in the United States today face a variety of challenges to their traditional business models. An aging grid makes substantial investment in maintaining and modernizing system infrastructure a looming need. Meanwhile, myriad factors are making kWh sales decay a real concern, threatening the traditional mechanism by which regulated utilities recover costs and earn allowed market returns associated with infrastructure investment, as well as threatening the business model for all other types of utilities. These factors include:

- The falling costs and growing adoption of distributed generation (DG) and the prevalence of net-metering policies for integrating that DG
- Flat or even declining electricity demand, driven in part by increasing energy efficiency efforts as well as expanding demand-side strategies to manage electricity consumption

In addition, the electricity sector faces increasing social and regulatory pressures to reduce the carbon intensity and other environmental and health impacts of power generation.

Together, these forces undermine the "old" model of central power generation, transmission, and distribution. In particular, the combination of increasing costs and declining revenues creates upward price pressure. Yet higher retail electricity prices further prompt customers to invest in efficiency and distributed generation, creating a self-reinforcing cycle sometimes known as the utility death spiral.

The idea of a utility death spiral, while not new, is increasingly relevant in its potential reality. Once upon a time, the utility death spiral was considered a potential outcome of efficiency. The growth of grid-connected distributed generation later added to death spiral concern. And while some customers have more choice than others, the trend of increasing options for electricity supply is likely here to stay. Now, there's also a fundamentally different growing threat and emerging opportunity wrapped up into one: combined distributed generation and energy storage. Other challenges, such as DG alone and energy efficiency, still maintain customers' grid dependence. Combined DG and storage, and in particular, solar-plus-battery systems, give a customer the option to go from grid connected to grid defected—customers could secede from the macro grid entirely.

Utilities have recently acknowledged this day could come. The Edison Electric Institute's January 2013 report, *Disruptive Challenges,* noted:

> Due to the variable nature of renewables, there is a perception that customers will always need to remain on the grid. While we would expect customers to remain on the grid until a fully viable and economic distributed non-variable resource is available, one can imagine a day when battery storage technology or micro turbines could allow customers to be electric grid independent.

Two mutually reinforcing accelerants—declining costs for distributed energy technologies and increasing adoption of those technologies—are rapidly transforming the electricity market in ways that suggest grid parity (i.e., economic and technical service equality with the electrical grid) for solar-plus-battery systems is coming sooner than many had anticipated.

Declining Costs for Distributed Energy Technologies

Trends for Solar PV

The distributed U.S. solar industry has experienced robust growth in recent years, delivering an average annual installed capacity increase of 62% from 2010 to 2012. Lower hardware costs (largely thanks to the collapse in PV module prices) and the rapid expansion of third-party financing for residential and commercial customers have fueled this growth.

Bronski, Peter, et al. "The Economics of Grid Defection" Copyright ©2014 Rocky Mountain Institute. Reprinted by permission. All rights reserved.

We expect solar PV's levelized cost of energy (LCOE) to continue to decline through 2020 and beyond, despite both the likely end of the residential renewable energy tax credit and the reduction (from 30% to 10%) of the business energy investment tax credit in 2016. Further drops in upfront costs per installed Watt and additional improvements in solar PV finance (i.e., reduced cost of capital) will help drive the continued declines in solar PV's LCOE.

Trends for Battery Technology

Electric vehicle (EV) market growth has driven the lithium-ion (Li-ion) battery industry's recent expansion. Though it lags behind the growth of the solar PV market, it has still been significant in recent years. Coupled with greater opportunities for on-grid energy storage, including those enabled by regulations such as the Federal Energy Regulatory Commission's (FERC) Order 755 and California's AB 2514, battery demand is surging. Opportunities in both the vehicle and grid markets will continue to drive the energy storage industry for the foreseeable future, yielding lower costs for batteries for mobile and stationary applications.

Support Technologies Unlock More Value

The evolution of support systems—including improved energy systems controls—is progressing apace. Synergistically, these controls have improved the value proposition of solar PV and batteries, thus creating further demand. In addition, smart inverters have seen price reductions and continue to offer new capabilities, unlocking new opportunities for their application and the increased integration of distributed energy resources.

Given the fast-moving technology landscape, we took a conservative view that represents steady progress and is aligned with published projections. However, with high innovation rates in solar, storage, and support technologies, it is conceivable that we underestimate progress in our base case.

Forces Driving Adoption of Off-Grid Systems

Based on our research and interviews with subject matter experts, we identified at least five forces driving the increased adoption of off-grid hybrid distributed generation and storage systems:

- Interest in reliability and resilience
- Demand for cleaner energy
- Pursuit of better economics
- Utility and grid frustration
- Regulatory changes

Interest in Reliability and Resilience

From severe weather events such as Superstorm Sandy, to direct physical attacks on grid infrastructure in Arkansas and Silicon Valley, to reports on the potential for major system damage from geomagnetic storms, the fragility of the U.S. electric grid is now a nearly constant media topic. As a byproduct of the U.S.'s early advance into the electrical age, our systems are among the oldest on the planet and experience triple the frequency disruptions and ten times the duration of system outages compared to some OECD peer nations such as Germany and Denmark. In fact, in little over a decade, the U.S. has witnessed some of the most severe power outages in its history.

An increasingly popular solution to these reliability challenges is islandable microgrids, which produce and consume power locally in small, self-balancing networks capable of separating from and rejoining the larger grid on demand. They have a point of common coupling to the grid, and include both generation and loads that can be managed in a coordinated manner. Navigant Research forecasts the microgrid market to reach as high as $40 billion in the U.S. by 2020.

A more extreme example of this trend, yet similarly connected to reliability and resilience interests, is permanently off-grid buildings. Prior to 2000 off-grid solar installations made up over 50% of solar PV projects. While currently a minute portion of total solar PV sales, such off-grid solar has actually continued its growth in absolute sales. Though the majority of solar PV was off grid prior to 2000 primarily because it was used in remote locations where grid connection was a more difficult and expensive proposition, we're likely in the midst of a new era of off-grid solar PV (with batteries) within grid-accessible locations. The conversation has shifted from being off grid out of necessity to being off grid out of choice.

Demand for Cleaner Energy

Demand for cleaner energy with a lower carbon intensity and softer environmental footprint is on the rise.

On the commercial side, major corporations such as Walmart, Costco, IKEA, and Apple are increasingly "going solar." According to the World Wildlife Fund's *Power Forward* report, nearly 60% of Fortune 100 and Global 100 companies have renewable energy targets, greenhouse gas emissions goals, or both. These commitments are driving increased investment in renewable energy, including

distributed solar PV. As of mid-2013, cumulative U.S. commercial solar installations totaled 3,380 MW, a 40% increase over the previous year.

On the residential side, a 2012 survey of nearly 200 solar homeowners found that even if solar's economics weren't favorable, 1 in 4 would *still* have chosen to install a solar PV system because of their passion for the environment. An earlier survey of more than 640 solar installs—primarily residential—found that reducing one's carbon footprint ranked nearly equal with reducing one's energy bill among the top reasons customers chose to go solar. Small residential applications for completely off-grid homes have existed within the United States for many years. These homes and businesses were usually owned by the environmentally-driven consumer, as these buildings had to be energy sippers, because of the then-high cost of renewable energy technologies such as solar, wind, and storage.

Pursuit of Better Economics

Most remote locations without substantial energy infrastructure—like many islands—have been largely dependent on diesel fuel and diesel gensets to meet their electrical needs. In places such as Hawaii, Puerto Rico, Alaskan villages, and the U.S. Virgin Islands, expensive imported petroleum (e.g., diesel, fuel oil) provides 68%–99% of electricity generation, resulting in retail electricity prices of $0.36–$0.50 per kWh or more.

Thus on islands and anywhere with high retail electricity prices, there is a strong economic case for reducing the use of diesel fuel as a primary fuel source for electrical power, especially considering that the retail price of diesel in the U.S. has increased 233%-real in the past 15 years.

Yet in 2013, liquid fuels were used for nearly 5% of global electricity production, accounting for 948 billion kilowatt-hours of generation, 387 GW of installed capacity, and nearly 5 million barrels/day of fuel consumption. Further, projections from a new Navigant Research report suggest that annual installations of standby diesel generators will reach 82 GW per year by 2018, signifying a growing opportunity for solar-plus-battery systems.

Utility and Grid Frustration

While in the past the grid barely warranted a second thought for most people, sentiment is changing. This change will only get worse as interconnection delays and red tape, arguments over net metering, and potentially rising prices continue to affect consumers. This reputational erosion poses additional challenges to utilities, above and beyond the increasingly competitive economics of off-grid solutions.

For example, in Hawaii, where utility interconnection limitations are making it impossible for many customers to take on grid-connected solar, off-grid development is increasing. Similar desires from individuals for some semblance of energy independence—particularly the right to garner external financing for systems on their private property—led to an unlikely political alliance between conservatives and liberals in Georgia in 2012, as well as current, similarly across-the-aisle political activities in Arizona.

Regulatory Changes

Rapid scaling of solar PV, and now grid-connected solar-plus-battery systems, are requiring federal, utility, state, and local regulators to explore new regulatory frameworks. Distributed generation and storage don't fit neatly into the traditional utility model of generation, distribution, and load or existing pricing structures that recover utilities' fixed costs through energy sales.

In California, where battery storage targets and incentives have made solar-plus-battery systems more attractive, utilities including Southern California Edison, PG&E, and Sempra Energy have made it challenging for system owners with storage to net meter their power. The utilities expressed concern that customers could store grid electricity on their batteries and then sell it back to the grid at higher prices. This upset current customers who have had battery storage for some time and were surprised by the utilities' decisions. The matter impacts both California Public Utility Commission regulation as well as the state's Renewable Portfolio Standard.

Perceived negative outcomes from regulation can drive customers, who desire solar PV and batteries for other factors, to pursue off-grid solutions.

In addition, incentives to promote storage could accelerate battery price declines, thereby increasing uptake of off-grid solutions. Several pro-storage regulations have recently been enacted. While they were primarily created with grid connectivity in mind, the overall development of the storage market and accompanying controls and other integration systems likely will lead to more robust and affordable off-grid storage applications. . . .

Conclusion

Rising retail electricity prices (driven in part by rising utility costs), increasing energy efficiency, falling costs for distributed energy technologies such as solar-plus-battery systems, and increasing adoption of distributed energy options are fundamentally shifting the landscape of the electricity system. Our analysis shows that solar-plus-battery

systems will reach grid parity—for growing numbers of customers in certain geographies, especially those with high retail electricity prices—well within the 30-year period by which utilities capitalize major power assets. Millions of customers, commercial earlier than residential, representing billions of dollars in utility revenues will find themselves in a position to cost effectively defect from the grid if they so choose.

The so-called utility death spiral is proving not just a hypothetical threat, but a real, near, and present one. The coming grid parity of solar-plus-battery systems in the foreseeable future, among other factors, signals the eventual demise of traditional utility business models. Furthermore, early adopters and kWh sales decay will make utilities feel the pinch even before the rapidly approaching day of grid parity is here, while more aggressive technology improvements and investments in demand-side improvements beyond our base case would accelerate grid parity. Though utilities could and should see this as a threat, especially if they cling to increasingly challenged legacy business models, they can also see solar-plus-battery systems as an opportunity to add value to the grid and their business. When solar-plus-battery systems are integrated into a network, new opportunities open up that generate even greater value for customers and the network (e.g., potentially better customer-side economics, additional sizing options, ability of distributed systems to share excess generation or storage). The United States' electric grid is in the midst of transformation, but that shift need not be an either/or between central and distributed generation. Both forms of generation, connected by an evolving grid, have a role to play.

Having conducted an analysis of when and where grid parity will happen in this report, the important next question is how utilities, regulators, technology providers, and customers might work together to reshape the market—either within existing regulatory frameworks or under an evolved regulatory landscape—to tap into and maximize new sources of value offered by these disruptive opportunities to build the best electricity system of the future that delivers value and affordability to customers and society. The implications of these disruptive opportunities on business model design are the subject of ongoing work by the authors and their institutions, covered in a forthcoming report to follow soon.

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Disruptive Challenges: Financial Implications and Strategic Responses to a Changing Retail Electric Business

Executive Summary

Recent technological and economic changes are expected to challenge and transform the electric utility industry. These changes (or "disruptive challenges") arise due to a convergence of factors, including: falling costs of distributed generation and other distributed energy resources (DER); an enhanced focus on development of new DER technologies; increasing customer, regulatory, and political interest in demand-side management technologies (DSM); government programs to incentivize selected technologies; the declining price of natural gas; slowing economic growth trends; and rising electricity prices in certain areas of the country. Taken together, these factors are potential "game changers" to the U.S. electric utility industry, and are likely to dramatically impact customers, employees, investors, and the availability of capital to fund future investment. The timing of such transformative changes is unclear, but with the potential for technological innovation (e.g., solar photovoltaic or PV) becoming economically viable due to this confluence of forces, the industry and its stakeholders must proactively assess the impacts and alternatives available to address disruptive challenges in a timely manner.

This paper considers the financial risks and investor implications related to disruptive challenges, the potential strategic responses to these challenges, and the likely investor expectations to utility plans going forward. There are valuable lessons to be learned from other industries, as well as prior utility sector paradigm shifts, that can assist us in exploring risks and potential strategic responses.

The financial risks created by disruptive challenges include declining utility revenues, increasing costs, and lower profitability potential, particularly over the long-term. As DER and DSM programs continue to capture "market share," for example, utility revenues will be reduced. Adding the higher costs to integrate DER, increasing subsidies for DSM and direct metering of DER will result in the potential for a squeeze on profitability and, thus, credit metrics. While the regulatory process is expected to allow for recovery of lost revenues in future rate cases, tariff structures in most states call for non-DER customers to pay for (or absorb) lost revenues. As DER penetration increases, this is a cost-recovery structure that will lead to political pressure to undo these cross subsidies and may result in utility stranded cost exposure.

While the various disruptive challenges facing the electric utility industry may have different implications, they all create adverse impacts on revenues, as well as on investor returns, and require individual solutions as part of a comprehensive program to address these disruptive trends. Left unaddressed, these financial pressures could have a major impact on realized equity returns, required investor returns, and credit quality. As a result, the future cost and availability of capital for the electric utility industry would be adversely impacted. This would lead to increasing customer rate pressures.

The regulatory paradigm that has supported recovery of utility investment has been in place since the electric utility industry reached a mature state in the first half of the 20th century. Until there is a significant, clear, and present threat to this recovery paradigm, it is likely that the financial markets will not focus on these disruptive challenges, despite the fact that electric utility capital investment is recovered over a period of 30 or more years (i.e., which exposes the industry to stranded cost risks). However, with the current level of lost load nationwide from DER being less than 1 percent, investors are not taking notice of this phenomenon, despite the fact that the pace of change is increasing and will likely increase further as costs of disruptive technologies benefit further from scale efficiencies.

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Investors, particularly equity investors, have developed confidence throughout time in a durable industry financial recovery model and, thus, tend to focus on earnings growth potential over a 12- to 24-month period.

So, despite the risks that a rapidly growing level of DER penetration and other disruptive challenges may impose, they are not currently being discussed by the investment community and factored into the valuation calculus reflected in the capital markets. In fact, electric utility valuations and access to capital today are as strong as we have seen in decades, reflecting the relative safety of utilities in this uncertain economic environment.

In the late 1970s, deregulation started to take hold in two industries that share similar characteristics with the electric utility industry—the airline industry and the telecommunications industry (or "the telephone utility business"). Both industries were price- and franchise-regulated, with large barriers to entry due to regulation and the capital-intensive nature of these businesses. Airline industry changes were driven by regulatory actions (a move to competition), and the telecommunications industry experienced technology changes that encouraged regulators to allow competition. Both industries have experienced significant shifts in the landscape of industry players as a result.

In the airline sector, each of the major U.S. carriers that were in existence prior to deregulation in 1978 faced bankruptcy. The telecommunication businesses of 1978, meanwhile, are not recognizable today, nor are the names of many of the players and the service they once provided ("the plain old telephone service"). Both industries experienced poor financial market results by many of the former incumbent players for their investors (equity and fixed-income) and have sought mergers of necessity to achieve scale economies to respond to competitive dynamics.

The combination of new technologies, increasing costs, and changing customer-usage trends allow us to consider alternative scenarios for how the future of the electric sector may develop. Without fundamental changes to regulatory rules and recovery paradigms, one can speculate as to the adverse impact of disruptive challenges on electric utilities, investors, and access to capital, as well as the resulting impact on customers from a price and service perspective. We have the benefit of lessons learned from other industries to shift the story and move the industry in a direction that will allow for customers, investors, and the U.S. economy to benefit and prosper.

Revising utility tariff structures, particularly in states with potential for high DER adoption, to mitigate (or eliminate) cross subsidies and provide proper customer price signals will support economic implementation of DER while limiting stress on non-DER participants and utility finances. This is a near-term, must-consider action by all policy setting industry stakeholders.

The electric utility sector will benefit from proactive assessment and planning to address disruptive challenges. Thirty year investments need to be made on the basis that they will be recoverable in the future in a timely manner. To the extent that increased risk is incurred, capital deployment and recovery mechanisms need to be adapted accordingly. The paper addresses possible strategic responses to competitive threats in order to protect investors and capital availability. While the paper does not propose new business models for the industry to pursue to address disruptive challenges in order to protect investors and retain access to capital, it does highlight several of the expectations and objectives of investors, which may lead to business model transformation alternatives.

Background

As a result of a confluence of factors (i.e., technological innovation, public policy support for sustainability and efficiency, declining trends in electricity demand growth, rising price pressures to maintain and upgrade the U.S. distribution grid, and enhancement of the generation fleet), the threat of disruptive forces (i.e., new products/markets that replace existing products/markets) impacting the utility industry is increasing and is adding to the effects of other types of disruptive forces like declining sales and end-use efficiency. While we cannot lay out an exact roadmap or timeline for the impact of potential disruptive forces, given the current shift in competitive dynamics, the utility industry and its stakeholders must be prepared to address these challenges in a way that will benefit customers, long-term economic growth, and investors. Recent business history has provided many examples of companies and whole industries that either failed or were slow to respond to disruptive forces and suffered as a result.

Today, a variety of disruptive technologies are emerging that may compete with utility-provided services. Such technologies include solar photovoltaics (PV), battery storage, fuel cells, geothermal energy systems, wind, micro turbines, and electric vehicle (EV) enhanced storage. As the cost curve for these technologies improves, they could directly threaten the centralized utility model. To promote the growth of these technologies in the near-term, policymakers have sought to encourage disruptive competing energy sources through various subsidy programs, such as tax incentives, renewable portfolio standards, and net metering where the pricing structure of utility services

allows customers to engage in the use of new technologies, while shifting costs/lost revenues to remaining non-participating customers.

In addition, energy efficiency and DSM programs also promote reduced utility revenues while causing the utility to incur implementation costs. While decoupling recovery mechanisms, for example, may support recovery of lost revenues and costs, under/over recovery charges are typically imposed based on energy usage and, therefore, adversely impact non-participants of these programs. While the financial community is generally quite supportive of decoupling to capture lost revenues, investors have not delved into the long-term business and financial impact of cross subsidization on future customer rates inherent in most decoupling models and the effective recovery thereof. In other words, will non-DER participants continue to subsidize participants or will there be political pressure to not allow cost pass thru over time?

The threat to the centralized utility service model is likely to come from new technologies or customer behavioral changes that reduce load. Any recovery paradigms that force cost of service to be spread over fewer units of sales (i.e., kilowatt-hours or kWh) enhance the ongoing competitive threat of disruptive alternatives. While the cost—recovery challenges of lost load can be partially addressed by revising tariff structures (such as a fixed charge or demand charge service component), there is often significant opposition to these recovery structures in order to encourage the utilization of new technologies and to promote customer behavior change.

But, even if cross-subsidies are removed from rate structures, customers are not precluded from leaving the system entirely if a more cost-competitive alternative is available (e.g., a scenario where efficient energy storage combined with distributed generation could create the ultimate risk to grid viability). While tariff restructuring can be used to mitigate lost revenues, the longer-term threat of fully exiting from the grid (or customers solely using the electric grid for backup purposes) raises the potential for irreparable damages to revenues and growth prospects. This suggests that an old-line industry with 30-year cost recovery of investment is vulnerable to cost-recovery threats from disruptive forces.

Generators in organized, competitive markets are more directly exposed to threats from new technologies and enhanced efficiency programs, both of which reduce electricity use and demand. Reduced energy use and demand translate into lower prices for wholesale power and reduced profitability. With reduced profitability comes less cash flow to invest and to support the needs of generation customers. While every market-driven business is subject to competitive forces, public policy programs that provide for subsidized growth of competing technologies and/or participant economic incentives do not provide a level playing field upon which generators can compete fairly against new entrants. As an example, subsidized demand response programs or state contracted generation additions create threats to the generation owner (who competes based upon free market supply and demand forces).

According to the Solar Electric Power Association (SEPA), there were 200,000 distributed solar customers (aggregating 2,400 megawatts or MW) in the United States as of 2011. Thus, the largest near-term threat to the utility model represents less than 1 percent of the U.S. retail electricity market. Therefore, the current level of activity can be "covered over" without noticeable impact on utilities or their customers. However, at the present time, 70 percent of the distributed activity is concentrated within 10 utilities, which obviously speaks to the increased risk allocated to a small set of companies. As previously stated, due to a confluence of recent factors, the threat to the utility model from disruptive forces is now increasingly viable. One prominent example is in the area of distributed solar PV, where the threats to the centralized utility business model have accelerated due to:

- The decline in the price of PV panels from $3.80/watt in 2008 to $0.86/watt in mid-2012. While some will question the sustainability of cost-curve trends experienced, it is expected that PV panel costs will not increase (or not increase meaningfully) even as the current supply glut is resolved. As a result, the all-in cost of PV solar installation approximates $5/watt, with expectations of the cost declining further as scale is realized;
- An increase in utility rates such that the competitive price opportunity for PV solar is now "in the market" for approximately 16 percent of the U.S. retail electricity market where rates are at or above $0.15/kWh. In addition, projections by PV industry participants suggest that the "in the money" market size will double the share of contestable revenue by 2017 (to 33 percent, or $170 billion of annual utility revenue);
- Tax incentives that promote specific renewable resources, including the 30-percent Investment Tax Credit (ITC) that is effective through 2016 and five-year accelerated depreciation recovery of net asset costs;

- Public policies to encourage renewable resource development through Renewable Portfolio Standards (RPS), which are in place in 29 states and the District of Columbia and which call for renewable generation goals within a state's energy mix;
- Public policies to encourage net metering, which are in effect in 43 states and the District of Columbia (3 additional states have utilities with voluntary net metering programs) and which typically allow customers to sell excess energy generated back to the utility at a price greater than the avoided variable cost;
- Time-of-use rates, structured for higher electric rates during daylight hours, that create incentives for installing distributed solar PV, thereby taking advantage of solar benefit (vs. time-of-use peak rates) and net metering subsidies; and
- The evolution of capital markets' access to businesses that leverage the dynamics outlined above to support a for-profit business model. Examples include tax equity financing, project finance lending, residential PV leasing models (i.e., "no money down" for customers), and public equity markets for pure play renewable resource providers and owners. As an illustration, U.S. tax equity investment is running at $7.5 billion annualized for 2012. Add other sources of capital, including traditional equity, and this suggests the potential to fund a large and growing industry.

Bloomberg New Energy Finance (BNEF) projects that distributed solar capacity will grow rapidly as a result of the competitive dynamics highlighted. BNEF projects 22-percent compound annual growth in PV installations through 2020, resulting in 30 gigawatts (GW) of capacity overall (and approximately 4.5 GW coming from distributed PV). This would account for 10 percent of capacity in key markets coming from distributed resources and even a larger share of year-round energy generated.

Assuming a decline in load, and possibly customers served, of 10 percent due to DER with full subsidization of DER participants, the average impact on base electricity prices for non-DER participants will be a 20 percent or more increase in rates, and the ongoing rate of growth in electricity prices will double for non-DER participants (before accounting for the impact of the increased cost of serving distributed resources). The fundamental drivers previously highlighted could suggest even further erosion of utility market share if public policy is not addressed to normalize this competitive threat.

While the immediate threat from solar PV is location dependent, if the cost curve of PV continues to bend and electricity rates continue to increase, it will open up the opportunity for PV to viably expand into more regions of the country. According to ThinkEquity, a boutique investment bank, as the installed cost of PV declines from $5/watt to $3.5/watt (a 30-percent decline), the targeted addressable market increases by 500 percent, including 18 states and 20 million homes, and customer demand for PV increases by 14 times. If PV system costs decline even further, the market opportunity grows exponentially. In addition, other DER technologies being developed may also pose additional viable alternatives to the centralized utility model.

Due to the variable nature of renewable DER, there is a perception that customers will always need to remain on the grid. While we would expect customers to remain on the grid until a fully viable and economic distributed non-variable resource is available, one can imagine a day when battery storage technology or micro turbines could allow customers to be electric grid independent. To put this into perspective, who would have believed 10 years ago that traditional wire line telephone customers could economically "cut the cord?"

The cost of providing interconnection and back-up supply for variable resources will add to the utility cost burden. If not properly addressed in the tariff structure, the provision of these services will create additional lost revenues and will further challenge non-DER participants in terms of being allocated costs incurred to serve others.

Another outcome of the trend of rising electricity prices is the potential growth in the market for energy efficiency solutions. Combining electricity price trends, customer sustainability objectives, and ratemaking incentives via cross-subsidies, it is estimated that spending on energy efficiency programs will increase by as much as 300 percent from 2010 to 2025, within a projected range of $6 to $16 billion per year. This level of spending on energy efficiency services will have a meaningful impact on utility load and, thus, will create significant additional lost revenue exposure.

The financial implications of these threats are fairly evident. Start with the increased cost of supporting a network capable of managing and integrating distributed generation sources. Next, under most rate structures, add the decline in revenues attributed to revenues lost from sales foregone. These forces lead to increased revenues required from remaining customers (unless fixed costs are recovered through a service charge tariff structure) and sought through rate increases. The result of higher electricity prices and competitive threats will encourage a higher rate

of DER additions, or will promote greater use of efficiency or demand-side solutions.

Increased uncertainty and risk will not be welcomed by investors, who will seek a higher return on investment and force defensive-minded investors to reduce exposure to the sector. These competitive and financial risks would likely erode credit quality. The decline in credit quality will lead to a higher cost of capital, putting further pressure on customer rates. Ultimately, capital availability will be reduced, and this will affect future investment plans. The cycle of decline has been previously witnessed in technology-disrupted sectors (such as telecommunications) and other deregulated industries (airlines).

Disruptive Threats—Strategic Considerations

A disruptive innovation is defined as "an innovation that helps create a new market and value network, and eventually goes on to disrupt an existing market and value network (over a few years or decades), displacing an earlier technology. The term is used in business and technology literature to describe innovations that improve a product or service in ways that the market does not expect, typically first by designing for a different set of consumers in the new market and later by lowering prices in the existing market."

Disruptive forces, if not actively addressed, threaten the viability of old-line exposed industries. Examples of once-dominant, blue chip companies/entities being threatened or succumbing to new entrants due to innovation include Kodak and the U.S. Postal Service (USPS). For years, Kodak owned the film and related supplies market. The company watched as the photo business was transformed by digital technology and finally filed for bankruptcy in 2012.

Meanwhile, the USPS is a monopoly, government-run agency with a mission of delivering mail and providing an essential service to keep the economy moving. The USPS has been threatened for decades by private package delivery services (e.g., UPS and FedEx) that compete to offer more efficient and flexible service. Today, the primary threat to USPS' viability is the delivery of information by email, including commercial correspondence such as bills and bill payments, bank and brokerage statements, etc. Many experts believe that the USPS must dramatically restructure its operations and costs to have a chance to protect its viability as an independent agency.

Participants in all industries must prepare for and develop plans to address disruptive threats, including plans to replace their own technology with more innovative, more valuable customer services offered at competitive prices. The traditional wire line telephone players, including AT&T and Verizon, for example, became leaders in U.S. wireless telephone services, which over time could make the old line telephone product extinct. But these innovative, former old-line telephone providers had the vision to get in front of the trend to wireless and lead the development of non-regulated infrastructure networks and consumer marketing skills. As a result, they now hold large domestic market shares. In fact, they have now further leveraged technology innovation to create new products that expand their customer offerings.

The electric utility sector has not previously experienced a viable disruptive threat to its service offering due to customer reliance and the solid economic value of its product. However, a combination of technological innovation, public/regulatory policy, and changes in consumer objectives and preferences has resulted in distributed generation and other DER being on a path to becoming a viable alternative to the electric utility model. While investors are eager to support innovation and economic progress, they do not support the use of subsidies to attack the financial viability of their invested capital. Utility investors may not be opposed to DER technologies, but, in order for utilities to maintain their access to capital, it is essential that the financial implications of DER technologies be addressed so that non-DER participants and investors are not left to pay for revenues lost (and costs unrecovered) from DER participants. . . .

Strategic Implications of Distribution 2020 Disruptive Forces

The threats posed to the electric utility industry from disruptive forces, particularly distributed resources, have serious long-term implications for the traditional electric utility business model and investor opportunities. While the potential for significant immediate business impact is currently low (due to low DER participation to date), the industry and its stakeholders must begin to seriously address these challenges in order to mitigate the potential impact of disruptive forces, given the prospects for significant DER participation in the future.

One example of a significant potential adverse impact to utility investors stems from net metering. Utilities have witnessed the implementation of net metering rules in all

but a handful of states. Lost revenues from DER are being recovered from non-DER customers in order to encourage distributed generation implementation. This type of lost revenue recovery drives up the prices of those non-participating customers and creates the environment for ongoing loss of additional customers as the system cost is transferred to a smaller and smaller base of remaining customers.

Utility investors are not being compensated for the risks associated with customer losses resulting from increasing DER. It is difficult to identify a rate case in which the cost-of-capital implications of net metering were considered. At the point when utility investors become focused on these new risks and start to witness significant customer and earnings erosion trends, they will respond to these challenges. But, by then, it may be too late to repair the utility business model.

DER is not the only disruptive risk the industry faces. Energy efficiency and DSM programs that promote lower electricity sales pressure earnings required to support capital investment. Without a tariff structure that properly allocates fixed vs. variable costs, any structure for lost revenues would come at a cost to non-participating customers, who will then be more motivated to find alternatives to reduce their consumption. While it is not the objective of this paper to outline new business model alternatives to address disruptive challenges, there are a number of actions that utilities and stakeholders should consider on a timely basis to align the interests of all stakeholders, while avoiding additional subsidies for non-participating customers.

These actions include:

Immediate Actions:

- Institute a monthly customer service charge to all tariffs in all states in order to recover fixed costs and eliminate the cross-subsidy biases that are created by distributed resources and net metering, energy efficiency, and demand-side resources;
- Develop a tariff structure to reflect the cost of service and value provided to DER customers, being off-peak service, back-up interruptible service, and the pathway to sell DER resources to the utility or other energy supply providers; and
- Analyze revision of net metering programs in all states so that self-generated DER sales to utilities are treated as supply-side purchases at a market-derived price. From a load provider's perspective, this would support the adoption of distributed resources on economically driven bases, as opposed to being incentivized by cross subsidies.

Longer-term Actions:

- Assess appropriateness of depreciation recovery lives based on the economic useful life of the investment, factoring the potential for disruptive loss of customers;
- Consider a stranded cost charge in all states to be paid by DER and fully departing customers to recognize the portion of investment deemed stranded as customers depart;
- Consider a customer advance in aid of construction in all states to recover upfront the cost of adding new customers and, thus, mitigate future stranded cost risk;
- Apply more stringent capital expenditure evaluation tools to factor-in potential investment that may be subject to stranded cost risk, including the potential to recover such investment through a customer hook-up charge or over a shorter depreciable life;
- Identify new business models and services that can be provided by electric utilities in all states to customers in order to recover lost margin while providing a valuable customer service—this was a key factor in the survival of the incumbent telephone players post deregulation; and
- Factor the threat of disruptive forces in the requested cost of capital being sought.

Investors have no desire to sit by and watch as disruptive forces slice away at the value and financial prospects of their investment. While the utility sector provides an important public good for customers, utilities and financial managers of investments have a fiduciary responsibility to protect the value of invested capital. Prompt action to mitigate lost revenue, while protecting customers from cross-subsidization better aligns the interests of customers and investors.

As growth in earnings and value is a major component of equity investment returns, what will investors expect to see as a strategic response from the industry to disruptive forces? The way to realize growth in earnings is to develop profit streams to counterbalance the impact of disruptive forces. Examples of new profit sources would include ownership of distributed resources with the receipt of an ongoing service fee or rate basing the investment and financial incentives for utilities to encourage demand side/energy efficiency benefits for customers. From an investor perspective, this may be easier said than done because the history of the electric utility industry in achieving non-regulated profits/value creation streams has not been

a pleasant experience. So, investors will want to see very clear cut programs to capture value that are consistent with the core strengths of utilities: ability to execute construction projects, to provide dependable service with high reliability, and to access relatively low-cost capital.

Summary

While the threat of disruptive forces on the utility industry has been limited to date, economic fundamentals and public policies in place are likely to encourage significant future disruption to the utility business model. Technology innovation and rate structures that encourage cross subsidization of DER and/or behavioral modification by customers must be addressed quickly to mitigate further damage to the utility franchise and to better align interests of all stakeholders.

Utility investors seek a return on investment that depends on the increase in the value of their investment through growth in earnings and dividends. When customers have the opportunity to reduce their use of a product or find another provider of such service, utility earnings growth is threatened. As this threat to growth becomes more evident, investors will become less attracted to investments in the utility sector. This will be manifested via a higher cost of capital and less capital available to be allocated to the sector. Investors today appear confident in the utility regulatory model since the threat of disruptive forces has been modest to date. However, the competitive economics of distributed energy resources, such as PV solar, have improved significantly based on technology innovation and government incentives and subsidies, including tax and tariff-shifting incentives. But with policies in place that encourage cross subsidization of proactive customers, those not able or willing to respond to change will not be able to bear the responsibility left behind by proactive DER participating customers. It should not be left to the utility investor to bear the cost of these subsidies and the threat to their investment value.

This paper encourages an immediate focus on revising state and federal policies that do not align the interests of customers and investors, particularly revising utility tariff structures in order to eliminate cross subsidies (by non-DER participants) and utility investor cost-recovery uncertainties. In addition, utilities and stakeholders must develop policies and strategies to reduce the risk of ongoing customer disruption, including assessing business models where utilities can add value to customers and investors by providing new services.

While the pace of disruption cannot be predicted, the mere fact that we are seeing the beginning of customer disruption and that there is a large universe of companies pursuing this opportunity highlight the importance of proactive and timely planning to address these challenges early on so that uneconomic disruption does not proceed further. Ultimately, all stakeholders must embrace change in technology and business models in order to maintain a viable utility industry. . . .

Peter Kind is the executive director of Energy Infrastructure Advocates.

EXPLORING THE ISSUE

Is Home Solar the Wave of the Future?

Critical Thinking and Reflection

1. What do people mean when they call a technology "disruptive"?
2. What other industries might feel threatened by the growth in home solar power?
3. In what ways do early adopters of home solar power hasten the utility "death spiral"?

Is There Common Ground?

Both of our selections agree that the growing use of home solar power is likely to mean changes in the way that homeowners gain their electricity supply. To the Rocky Mountain Institute's team, these changes are desirable, for they promise lower prices, less dependence on fossil fuels, less contribution to global warming, and opportunities for utilities to retool their business models. To the electric utilities, these changes are not desirable, for they threaten loss of revenue, loss of investor confidence, and pressure to change traditional ways of doing business.

1. Both the Rocky Mountain Institute's team and Peter Kind agree that there is a need to identify new business models and services. What else can an electric utility do besides sell electricity?
2. Why do electric utilities need income even if they aren't selling electricity?
3. How can electric utilities take advantage of the trend toward home solar power?

Additional Resources

David Biello, "Solar Wars," *Scientific American* (November 2014).

Michael Boxwell, *Solar Electricity Handbook, 2014 Edition: A Simple Practical Guide to Solar Energy—Designing and Installing Photovoltaic Solar Electric Systems* (Greenstream, 2013).

John Schaeffer, *Real Goods Solar Living Sourcebook: Your Complete Guide to Living beyond the Grid with Renewable Energy Technologies and Sustainable Living* (New Society, 2014).

Internet References . . .

Rocky Mountain Institute

http://www.rmi.org/

The Edison Electric Institute

http://www.eei.org/Pages/default.aspx

Vivint Solar

http://www.vivintsolar.com/

Credits

1. Do We Have a Population Problem?: *Chapter by Easton, 2020* 1
2. Will Hydraulic Fracturing (Fracking) Negatively Affect Human Health and the Environment?: *Chapter by Daniel, 2020* 12
3. Should the United States Eliminate its Dependence on Foreign Oil?: *Chapter by Nielsen, Handler, 2014* 21
4. Would a Carbon Tax Help Slow Global Warming?: *Chapter by Easton, 2020* 37
5. Is it Necessary to Reduce Carbon Emissions to Fight Global Warming?: *Chapter by Easton, 2020* 57
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